THE ARMOUR ENGINEER

The Quarterly Technical Publication

OF THE

ARMOUR INSTITUTE OF TECHNOLOGY

CHICAGO, ILLINOIS

Volume XIII Number 1

November, 1921

The Armour Engineer

VOLUME XIII. NOVEMBER, 1921. NO. 1.

AUTOMOBILE BRAKES

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In a study of automobile brakes from the point of view of the accident hazard, it is important to emphasize strongly the fundamental principles of the mechanics of the problem. Accordingly, it is the purpose of these notes to discuss the mechanics of motion as applied to brakes and braking, then to discuss actual brake mechanisms and apply the principles to the analysis of typical braking systems including both external contracting and internal expanding types. Finally, brake lining materials will be briefly considered.

FUNDAMENTAL MECHANICS OF BRAKING:

It will be convenient, first of all, to give a list of the principal symbols and their meanings as used in the discussion.

Total weight of automobile with load........................W
Fractional part of total weight on rear wheels...............w
Speed of automobile in miles per hour.......................V
Speed of automobile in feet per second......................v
Diameter of rear wheels in inches...........................D
Diameter of brake drums in inches...........................d
Distance to stop, feet......................................S
Coefficient of friction between drum and lining..............f
Coefficient of friction between tire and ground..............F
Total friction on brake drums, lb...........................Q
Total braking friction of tires on ground, lb................R
Angle of contact on brake drums.............................Θ
Base of Naperian logarithms ....e

Pull on end of brake band—in direction opposite to friction. . T_1
Pull on end of brake band—in direction of friction. . . . . T_2
Acceleration of gravity, ft. per sec. per sec. . . . . g
Time required to bring car to rest, seconds. . . . . t
Negative acceleration of car coming to rest, feet per sec. per sec. . a

DISTANCE TO STOP.—In the case of an automobile in motion, the energy to be absorbed in bringing the car to rest is the total kinetic energy of the car. For the purposes of this discussion the kinetic energy due to the motion of translation of the car will be taken as a sufficient approximation to this total energy. This neglects the kinetic energy of rotation of the wheels. Expressed in the usual form the kinetic energy of translation is

$$E = \frac{Wv^2}{2g} \qquad (1)$$

Neglecting such minor influences as rolling and bearing friction, air resistance, etc., this energy must all be absorbed by the friction of the brakes on the brake drums. This friction tends to prevent rotation of the wheels to which the drums are attached (usually the rear wheels) and results in a drag or resistance being applied to the car as a whole. This resistance is applied at the contact of the rear tires with the road, (assuming rear wheel braking only), and gradually brings the car to rest. Although the speed of the car is being reduced, the co-efficient of friction (of rest) of the tires on the road may be assumed constant within the speed limits ordinarily considered. Experimental data show this to be justifiable.

On the foregoing assumption, the braking resistance throughout the stopping of the car will be constant and accordingly the work done in stopping the car is the product of this resistance and the distance through which the car moves after the brakes have been applied. Then the work of friction will be RS and will be equivalent to the kinetic energy of the car at the time the brakes were applied, or

$$RS = \frac{Wv^2}{2g} \qquad (2)$$

TIME TO STOP.—Although of less importance, it may be interesting to consider the expression showing the relation between braking force, kinetic energy and the time required to bring the car to rest after applying a constant braking force. Assuming the negative acceleration of the car in coming to rest to be constant (which follows directly from the assumption of a constant resistance while stopping) then by the well known relationships,

$$S = \tfrac{1}{2} at^2 \text{ and } a = \frac{v}{t}, \text{ we have}$$

$$S = \tfrac{1}{2}\frac{v}{t}t^2 = \tfrac{1}{2} vt \qquad (3)$$

Substituting this in equation (2) we have

$$R \tfrac{1}{2} vt = \frac{Wv^2}{2g}$$

Hence

$$R = \frac{Wv}{tg} \qquad (4)$$

Or

$$t = \frac{Wv}{Rg} \qquad (5)$$

BRAKING RESISTANCE.—It will now be of value to go further into detail in regard to the braking resistance at the ground or the value of R in the foregoing expressions. If this is taken at its maximum value the car will be brought to rest in the shortest distance and in the shortest time. These conditions being the most vital in this connection, the equations will be transformed accordingly and diagrams shown for conveniently reading off the results under any combination of weight, speed and braking effect. At this point it should be made clear that the braking effectiveness in the case of any automobile depends solely on the fact that there is friction between the tires of the wheels to which the brakes are applied and the road. It is obvious that if there were no friction at these wheels we should have to depend on other means such as air resistance. This being true, it should be noted

that the friction between any two bodies depends mainly on two things, viz., the pressure between the bodies and the coefficient of friction of the surfaces of contact. In the case of a car, the pressure above mentioned is the weight on the braking wheels and the coefficient of friction is that between the tires and the road surface.

Now in practice the weight of an ordinary type of passenger automobile on its rear or braking wheels is about 0.6 of the total loaded weight. This may be taken as a representative value. The coefficient of friction between the tires and the ground will, of course, vary considerably with the different kinds and conditions of road surface as well as tire tread and probably at high speeds it will be less than at low speeds. A fair maximum value based on experiments has been frequently given by good authority to be about 0.6. This maximum value comes into effect when the brakes have been applied with a force such that the tires are about to slip, i. e., when the wheels are about to "lock" and skid. After such skidding takes place the friction drag or resistance of the tires is less than before skidding because the coefficient of friction of motion is less than that of rest and the point of contact of wheels and road is relatively at rest while the wheels are still rolling.

Taking these values, we find that the maximum braking resistance probable under good conditions of road and intelligent operation of brakes, will be the product of weight on the braking tires and the coefficient of friction between tires and ground or numerically 0.6 W x 0.6 or 0.36 W. Substituting this for R in equation (2) we have

$$0.36\,W\,S = \frac{Wv^2}{2g} \quad \dots\dots\dots\dots (6)$$

If for convenience we take the speed V in miles per hour (remembering that 1.466 V = v in ft. per sec.),

$$0.36\,W\,S = \frac{W(1.466V)^2}{2g} \quad \dots\dots\dots\dots (7)$$

Or,

$$S = \frac{V^2}{10.8} = 0.0926V^2 \quad \dots\dots\dots\dots (8)$$

This, incidentally ,is the expression used by one of the well-known manufacturers of brake lining to determine the distance in feet in which a car should be able to stop at various speeds in miles per hour. The following table shows some results of applying the expression.

TABLE I

5	2.3	30	83.3
10	9.2	35	114.0
15	20.8	40	148.0
20	37.0	50	231.0
25	57.9		

The figure 10.8 represents a fair average of results of actual road tests. The range of the figure was found to be from 6.7 for unusually smooth roads to 17.4 for rough roads.

General Expression for Distance to Stop.—If equation (6) is put in more general terms including the coefficient of friction of tires with ground and weight on braking wheels we have

$$F\,w\,W\,S = \frac{Wv^2}{2g} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (9)$$

or converting v in feet per second to V in miles per hour and reducing to simplest form,

$$S = \frac{0.0334\,V^2}{Fw} \quad \ldots\ldots\ldots\ldots\ldots\ldots (10)$$

Equation (10) may be conveniently solved by using the nomograph, Fig. 1. The first step is to connect values of F and w by a straight line crossing the scale between them showing their product. Then a straight line from the point thus determined through any given value of V will intersect the scale for S at the corresponding distance in which the car will stop.

General Expression for Time to Stop.—The formula given as equation (5) may also be reduced by substituting for R its value F w W so that we have

$$t = \frac{v}{Fwg} \quad \ldots\ldots\ldots\ldots\ldots\ldots (11)$$

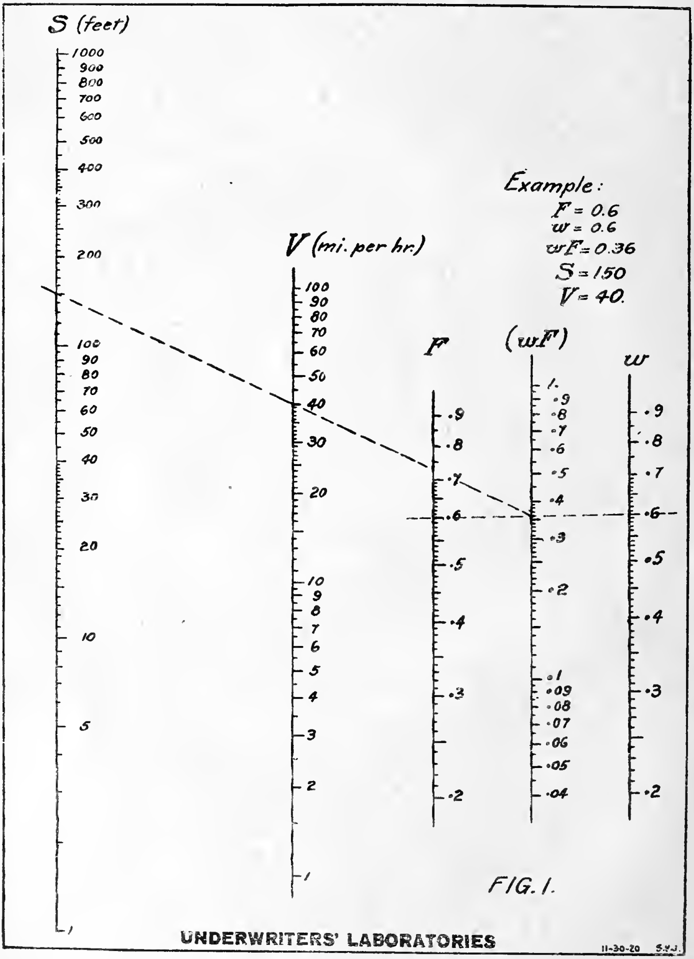

Fig. 1. Nomograph for Determining Distance in which a Car may be stopped with Brakes.

or, if we use V miles per hour,

$$t = \frac{1.466\ V}{32.2\ Fw} = \frac{0.0455\ V}{Fw} \quad \ldots\ldots\ldots\ldots\ldots\ldots (12)$$

BRAKE MECHANISMS:

Typical Forms.—In general, automobile brakes are either ot the external contracting or the internal expanding type. In the former, flexible steel bands with a friction lining may be brought to bear against the outer cylindrical surfaces of steel brake drums mounted either on the rear wheels directly or on an intermediate shaft such as the transmission shaft in the case of passenger cars and on the chain jack shaft in the case of trucks. The expanding brake consists of brake shoes or bands carrying lining material and so designed that they may be expanded against the inner cylindrical surfaces of the brake drums. Suitable linkage enables the brakes to be applied either by pressure of the foot on a pedal or the pull of the hand on a lever.

External Contracting Brake.—Fig. 2 shows in diagram form a typical contracting brake mechanism as applied to rear wheel drums. The pressure of the foot on the pedal is indicated by the arrow P. The moment arms of the various forces throughout the linkage are shown by the letters, h, k, l, m, etc., and are measured at right angles to the lines of the forces after the mechanism is moved so that the bands bear tightly against the drum. The groups of short parallel lines indicate pivots fixed relative to the car. The large circle of diameter D represents the tire; the circle of diameter d, the brake drum.

The force P on the pedal should be traced through the linkage up to the top of the bell crank or floating lever. The effective force P_1 at the upper end of this lever is

$$P_1 = P \left(\frac{h}{k} \cdot \frac{l}{m} \cdot \frac{n}{o}\right) \quad \ldots\ldots\ldots\ldots\ldots (13)$$

This indicates an increased advantage ordinarily. The length h is usually three or four times as great as k; l is sometimes greater, sometimes less than m, but in either case l is to be taken as the

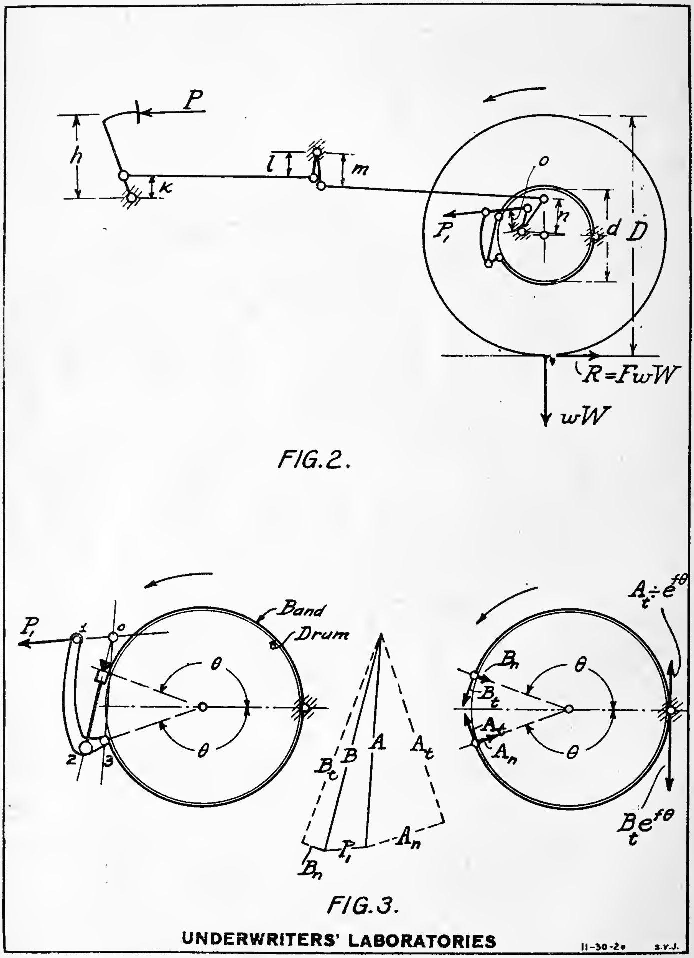

Fig. 2 Diagram of Ordinary Foot-operated Contracting Brake.
Fig. 3. Force Diagrams for Contracting Brake.

arm of the force in the rod from the pedal regardless of its magnitude relative to m; n is sometimes greater than o and usually about the same. Hence P_1 is generally several times as great as P; usually two to three times.

The forces on the bell crank must next be analyzed. See Fig. 3. This lever is a three-force piece. The magnitude, direction and point of application of P_1 are known. Likewise, the direction and point of application of the force B, on the end of the upper part of the band are known, since the link through which it is applied is connected by a pivot at its lower end and has a V-bearing at its upper end fitting. This leaves the third force, A, on the end of the lower band to be determined. We only know the point of application. Its direction and magnitude may be determined graphically by drawing the force triangle as indicated (all three forces must intersect in a point for equilibrium of a three-force piece).

The force A is a downward pull on point 3 of the bell crank but is an upward pull on the end of the lower part of the band. Similarly B is a downward pull on the upper part of the band. These forces on the ends of the band are then resolved into components normal and tangential to the band surface and are indicated in a separate part of Fig. 3 as A_n, B_n, A_t and B_t. The normal components multiplied by the coefficient of friction between lining and drum, f, give the braking effect of their normal forces at the drum surface: fA_n and fB_n.

The tangential components are dealt with differently. The fixed point of anchorage of the band opposite the ends virtually divides the band into two parts, upper and lower.

Considering forward motion, as indicated by an arrow, the force A_t acts in a direction opposite to that of the friction on the lower half of the band. Since the friction effect accumulates in the direction of motion, the force required to hold the fixed point of the band will be less than A_t, because the accumulated friction will reduce the necessary pull in the band at that point. The ratio of the greater to the lesser tension in any such case as (X)* where e is the base of Naperian logarithms, f is the coefficient of friction and Θ is the angle of contact (the derivation of the expression for this relationship may be found in any standard refer-

*(X denotes e raised to the power $f\theta$).

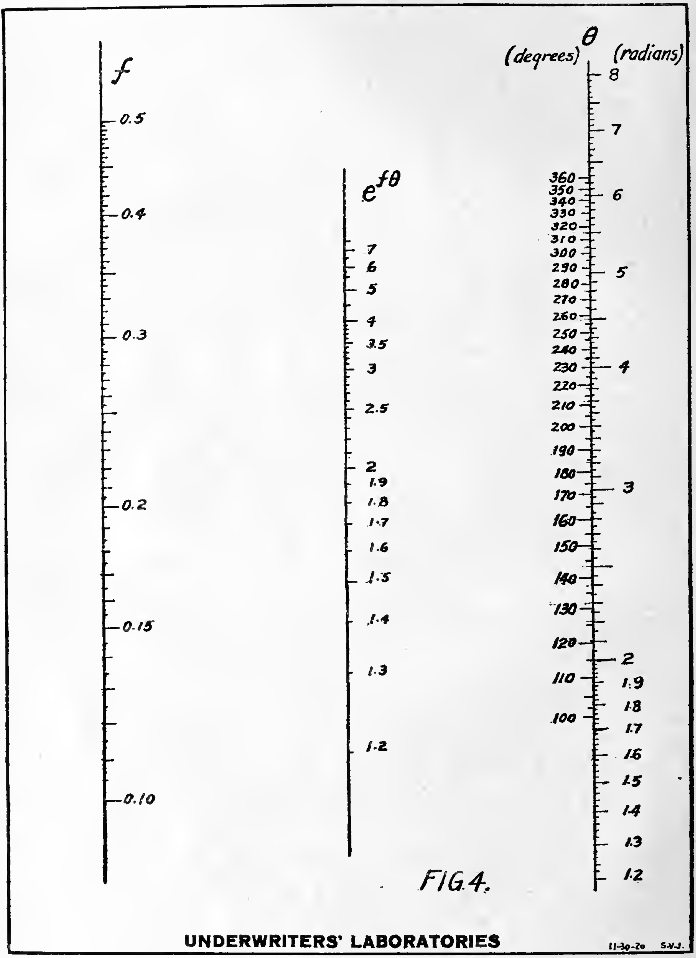

Fig. 4. Nomograph for determining e to the power $f\theta$.

ence on mechanics and is usually discussed under the subject of belts or brakes).

For the upper half of the band, the pull on the fixed point will be greater than the applied pull at the free end, because the pull at the fixed point is opposite to the direction of motion. With these relationships in mind, it will be easily be understood that the force at the fixed end of the lower part of the band is A $\div$ (X)* and the force at the fixed end of the upper part is B_t . (X)* The angle Θ is measured from the radius through the fixed pivot in the rear of the band to the radius through the end pivot of the band. The valves for upper and lower parts are approximately equal and this assumption is made.

The total friction on the drum consists of the sum of the differences between the end forces on the lower and upper parts of the band plus the friction of the normal components. Expressed in symbols this becomes

$$Q = \left(A_t - \frac{A_t}{e^{f\theta}}\right) + (B_t e^{f\theta} - B_t) + fA_n + fB_n$$

Or

$$Q = A_t \left(\frac{e^{f\theta} - 1}{e^{f\theta}}\right) + B_t(e^{f\theta} - 1) + f(A_n + B_n)$$

(14) and (15)

From the graphical analysis of the bell crank forces, all the components A_n, B_n, A_t and B_t are known in terms of the force P_1. Accordingly, they are known in terms of the force P on the pedal. Equation (15) and the preceding analysis will give us the total braking effect on the drums in terms of the force on the pedal. For convenience in applying this equation, Fig. 4 is given so that for any given or assumed values of f and Θ the corresponding value of (X)* may be readily determined. (If there are two drums, the actual forces at each drum will, of course, be half of the corresponding values of A_n, B_n, etc.). On Fig. 4, a straight line connecting values of f and Θ will intersect the center scale at the value of (X)*.

The next step is to transform the braking effect at the drum surfaces to that at the surface of the road. This is the ultimate object of this phase of the work. Referring again to Fig. 2, the

*(X denotes e raised to the power $f\theta$).

weight on the rear wheels is w W and if F is the coefficient of friction between tires and ground, the moment of the friction on the drums equals that of the tire friction. These friction forces act tangentially to the drums and tires respectively, hence heir moments are the friction forces times the respective radii, or

$$Q\frac{d}{2} = R\frac{d}{2} \quad \ldots\ldots\ldots\ldots\ldots\ldots (16)$$

Or,

$$R = Q\frac{d}{D} = F\,w\,W \quad \ldots\ldots\ldots\ldots\ldots\ldots (17)$$

Hence, if R is to be a maximum under good conditions of road surface, F equals 0.6, and w equals 0.6 or F w W = 0.36 W.

Mechanical Advantage.—If the brake mechanism is to allow maximum braking effort (0.36W) with a reasonable pressure on the pedal of, say, 100 lb., the mechanical advantage must be at least 0.36 W ÷ 100. This indicates that the proper mechanical advantage should be in direct proportion to the weight of the car and load if we assume the same proportion of the total weight on the braking tires and same efficient of friction of tires on road. Assume a car weighing, with load, 5000 lb., then the mechanical advantage of the service brake should be (0.36 x 5000) ÷ 100 or 18 times the brake pedal pressure. A lighter car weighing with load, say, 2000 lbs., would reuire (0.36 x 2000) ÷ 100 or 7.2 times the brake pedal pressure. This is the mechanical advantage necessary under the assumed conditions.

Application to a Specific Case.—The analysis previously discussed was applied in detail to an "Overland-Light Four." Measurement of the linkage showed the following values:

h = 12 inches	m = 3¼ inches
k = 3¼ inches	n = 3 inches
l = 3¼ inches	o = 3 inches

Therefore, by equation (13), $P_1 = \frac{12}{3.25} \times \frac{3\frac{1}{4}}{3\frac{1}{4}} \times \frac{3}{3} = 3.7$ P.

By graphical construction it was found that the forces at the drum had the following values:

$$A_t = 3.93\ P_1 = 14.55\ P \qquad A_n = 1.74\ P_1 = 6.44\ P$$
$$B_t = 3.87\ P_1 = 14.32\ P \qquad B_n = 0.52\ P_1 = 1.92\ P$$

Since $\Theta = 169°$ or 2.95 radians, and assuming f to be 0.3, e^{f} is $e^{0.885} = 2.43$. Accordingly, by equation (15).

$$Q = 14.55\ P\left(\frac{2.43 - 1}{2.43}\right) + 14.32\ P\ (2.43 - 1) + 0.3\ (6.44 + 1.92)\ P$$
$$= 8.56\ P + 20.30\ P + 2.51\ P = 31.37\ P.$$

The brake drum diameter was 10 in. and the wheel 30 in. Then by equation (17) $R = 31.37 \times 10/30 = 10.5P$. Hence if P is to be taken as a value of 100 lbs., the mechanical advantage is 10.5 to 1. A value of f = 0.3 was used here. Values ranging from 0.25 to 0.45 have been found as a result of test.

The weight of this car with a five-passenger body is 1940 lbs. Assuming five passengers averaging 150 lbs. each the total weight is 2960 lbs. For the good road conditions previously discussed the value of F w W will be 0.36 W, or in this case 968 lbs. This would require with 100 lbs. on the pedal, a mechanical advantage of about 9.7 to 1.

A test was made on this car by jacking up the rear axle, applying a 100-lb. load on the pedal (using a spring scale), then measuring the torque required to slip the brake band at one of the rear wheels. For the latter purpose a bar was clamped across the wheel and a pull applied at right angles to the bar at a known radius by using a spring scale. Reduced to the ground and tire contact a mechanical advantage of 12.0 to 1 was found. This value may be a trifle too high since the drum surfaces were somewhat rusty and the band linings new. The drum friction after a period of use would be less than that shown during this test. This would reduce the advantage slightly.

ANOTHER TYPE OF CONTRACTING BRAKE.—A type of contracting band brake sometimes used is shown by Fig. 5. Here is a fixed shaft carrying the short links, to the ends of which are at-

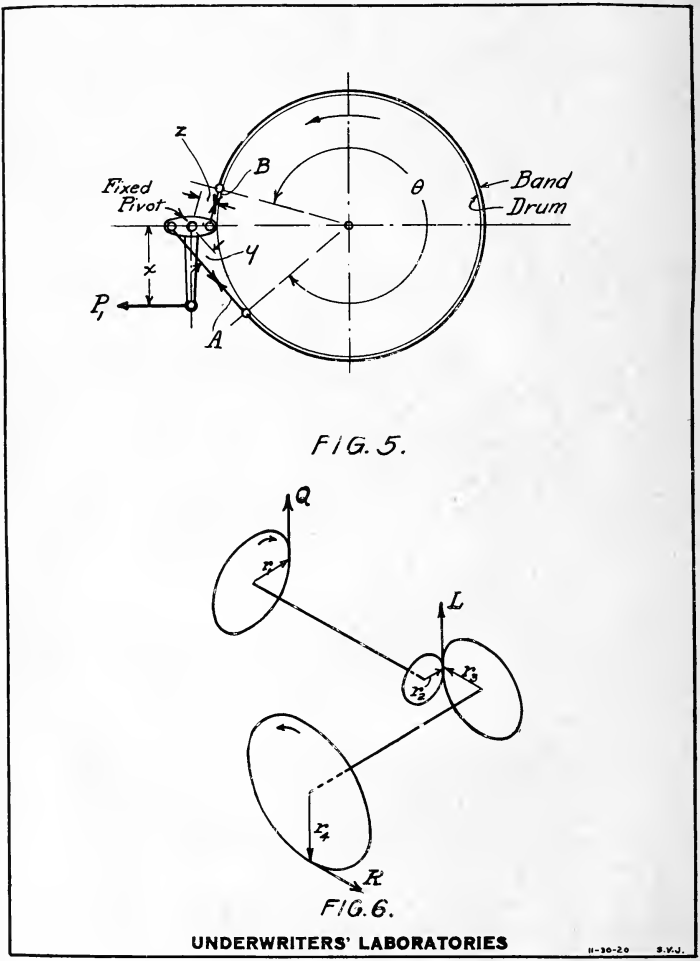

Fig. 5 Diagram of One-Piece Contracting Brake.
Fig. 6 Diagram of Leverage of Transmission Brake.

tached the continuous brake band as shown. An arm keyed to the shaft has a force P_1, applied to it through the linkage between the lower end and the pedal in the usual manner. There is a pull A on the lower end and another B, on the upper end of the band. The sum of the moments of these forces about the shaft equals that of the force P_1:

$$P_1x = Ay + Bz \qquad (18)$$

The friction on the drums is $Q = A - B$, for the direction of rotation shown, but

$$A = Be^{f\theta}, \text{ hence } B = \frac{Q}{e^{f\theta}-1} \text{ and } A = Q\frac{e^{f\theta}}{e^{f\theta}-1}$$

Substituting in eq. (18) we have

$$P_1x = Q\left(\frac{e^{f\theta}.y}{e^{f\theta}-1}\right) + Q\left(\frac{z}{e^{f\theta}-1}\right), \text{ or } Q = P_1\left(\frac{x(e^{f\theta}-1)}{e^{f\theta}y+z}\right)$$

(19)

From a measurement of the linkage between the pedal and the arm on the shaft, we know the value of P_1, in terms of P the pressure on the pedal. Equation (19) corresponds to equation (15) and gives the braking friction at the brake drums. This value must be multiplied by the ratio of the diameter of brake drum to diameter of wheel to give the effective value of the braking resistance at the ground. This has already been given in equation (17).

Expanding Brakes.—The methods used for the analysis of the other mechanisms already outlined may be readily adapted to internal brakes, bearing in mind that instead of a pull at each of the free ends of the band we have a push developed by some sort of cam or toggle mechanism designed to push the ends of the internal brake shoes apart, thus causing a pressure of the lining against the inside of the drum with the consequent friction developed. The pressure caused by the cam or toggle against the end faces of the shoes should be resolved graphically into tangential and normal components corresponding to A_t, B_t, A_n, and B_n, which appear in equation (15). An equation similar to (15)

*(X denotes e raised to the power $f\theta$).

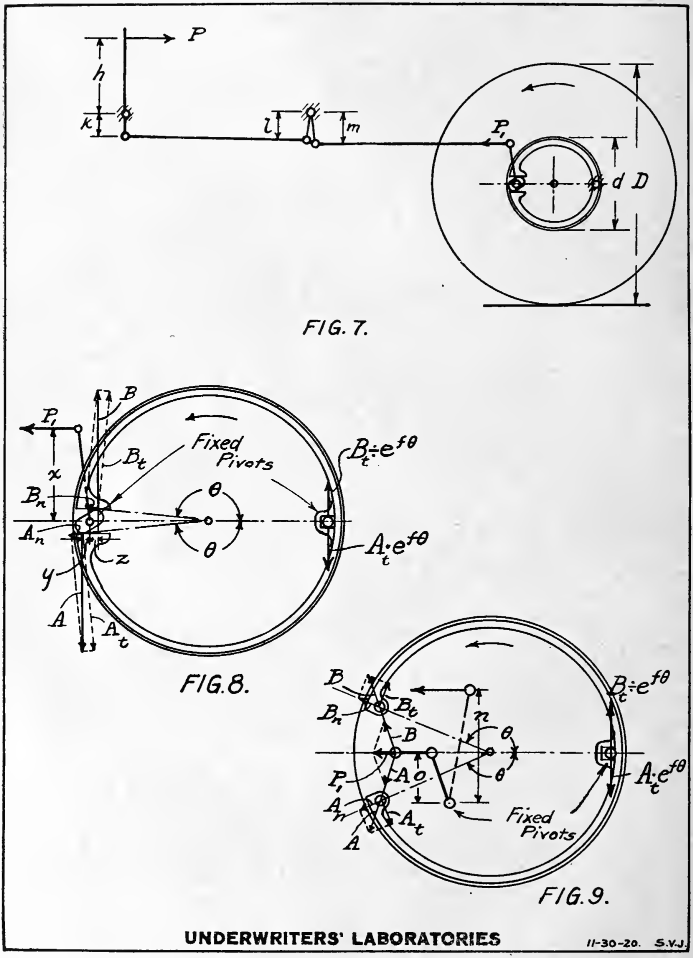

Fig. 7 Diagram of Hand operated Expanding Brake.

Fig. 8 Force Diagram for Expanding Brake.

Fig. 9 Force Diagram for Expanding Brake of Toggle Mechanism Type.

may then be employed to calculate the value of the braking friction Q at the brake drums. The application of the force to the cam toggle may be simply worked out by moments or by some graphical method and the braking effect thus found in terms of the pull on the hand lever.

Referring to Fig. 7 which shows diagrammatically the ordinary form of internal expanding brake mechanism, the pull P applied to the hand lever develops a pull P_1, at the top of the arm on the cross-shaft at the rear axle. The relation between these two forces is, as in the case of the contracting brake,

$$P_1 = P\left(\frac{h}{k} \cdot \frac{l}{m}\right)$$

A similar expression may be developed in case there are more elements in the linkage than those shown.

Referring to Fig. 8, showing the brake drum mechanism to an enlarged scale, the force P_1 has a moment arm x about the fixed shaft or pivot on which turns the cam for "expanding" the brake shoes. The pressure of the ends of the cam on the end faces of the shoes are A and B and these act at moment arms y and z respectively. Hence, to determine A and B, which are equal, we use the expression already developed as equation (18) which is repeated here:

$$P_1x = Ay + Bz$$

Having found A and B, we may graphically or otherwise resolve them in components A_t, A_n, B_t, B_n, respectively tangential and normal to the radii through the points of contact of cam and shoes as shown (The various force arrows in this figure and in Fig. 9 have not been shown to scale). As in the case of the contracting brake, the tangential forces coupled with lining friction, being about end forces at the fixed point at the rear. These forces under the condition of forward motion as shown by the arrows, are A_t, $(X)^*$ and $B_t \div (X)^*$. In other words, since the force A_t acts in the direction of accumulating friction on the lower half of the band, it develops a greater force at the fixed point and this force is found by analysis to be T_t $(X)^*$ Similarly the force

*(X denotes e raised to the power $f\theta$).

developed at the fixed point by the upper part is $B_t \div (X)$*, since friction and the end force B_t act in the opposite direction. Having found these forces, the total drum friction developed may be determined by using equation (15).

If a toggle mechanism is employed a very similar analysis may be made. Referring to Fig. 9 the forward pivot represents the shaft to which the arm receiving the pull from the brake linkage is attached. This arm is indicated by a dotted line with a force arrow at its upper end. An arm is fixed to the shaft inside the drum enclosure and has a short horizontal link at its upper end which is, in turn, connected to the ends of the internal band by inclined links as shown. The force on the short horizontal link is designated as P_1 and may be found, as in other cases, by the relation (the same as equation, (13),

$$P_1 = P\left(\frac{h}{k} \cdot \frac{l}{m} \cdot \frac{n}{o}\right)$$

By triangles of forces, this thrust is resolved into its components A and B in the inclined links of the toggle mechanism and these forces are again to be resolved at the band ends into tangential and normal components, A_t, A_n, B_t, and B_n. The forces at the rear fixed point are found in terms of A_t and B_t as before. Similarly the expression for the total band or drum friction is found by equation (15).

Effect of Rear Axle Ratio on Transmission Brakes.—In case of a mechanism having the brake drum mounted on the transmission shaft, the mechanical advantage figured from pedal to ground may be worked out in a manner similar to that already given, taking due account of the linkage. The ratio of the friction at the drum to that at the ground is affected by the rear axle gear ratio. This will be more clearly understood by reference to Fig. 6. The braking friction, Q, at the drum is applied at a radius of r_1. The ratio of r_3 to r_2 represents the gear ratio at the rear axle. The ground friction R, is acting at the radius of the wheel, r_4. Let L represent the tangential force applied at the gears due to the application of the friction Q. Then equating moments, we have

$$Qr_1 = Lr_2 \text{ or } L = Q\frac{r_1}{r_2} \quad \ldots\ldots\ldots\ldots (20)$$

$$Lr_3 = Rr_4 \text{ or } R = L\frac{r_3}{r_4} \quad \ldots\ldots\ldots\ldots (21)$$

Hence

$$R = Q\frac{r_3}{r_4} \cdot \frac{r_1}{r_2} \quad \ldots\ldots\ldots\ldots (22)$$

In this expression $r_1 \div r_4$ corresponds with $d \div D$ in equation (17). The ratio $r_3 \div r_2$ is the gear ratio which in practice ranges usually from 3 to 4.

BRAKE LINING:

It is interesting to note, see equation (15), that the total friction between brake lining and drum is dependent only on the coefficient of friction (f) between lining and drum surface, the angular extent of the circumference (Θ) embraced by the band and upon the forces applied to the ends of the band. It is independent of the diameter of the drum or the width of the brake band. The friction between lining and drum is due to the fact that there is a normal pressure between the lining and the drum caused by the forces at the ends of the band, and, if the end forces remain the same in amount and direction for different diameters and widths of drum the normal pressure, which will also remain constant, will be distributed over different areas of brake lining. It will thus be seen that a small narrow-faced drum will allow a relatively small area of brake lining and the highly concentrated normal pressure may exceed the safe value required for durability and reliability under service conditions. Accordingly, the drum diameter and band width should be so proportioned that the normal pressure will be distributed over a sufficient amount of lining surface to allow for long life of the lining and also to radiate the heat equivalent of the kinetic energy absorbed during braking without an unsafe rise in temperature.

The amount of normal pressure between lining and drum per square inch of lining material which should be allowed in practice may be determined by tests under various conditions as to pressure, speed of rubbing, thickness of lining and other factors. Different lining manufacturers have made such tests and have developed cerain recommendations based on their results. One of these companies gives, for example, the data contained in the following table:

TABLE II

Safe Working Pressures at Peripheral Speed of 500 to 600 ft. per min.

Thickness Inches	Pressure Lb. per sq. in.
$\frac{3}{16}$	100
$\frac{1}{4}$	115
$\frac{5}{16}$	130
$\frac{3}{8}$	150
$\frac{1}{2}$	175
$\frac{5}{8}$	200
$\frac{3}{4}$	250

Expressing the area of brake lining in other terms, the same manufacturer recommends that for 4000-lb. cars the area should be 5.9 to 6.5 sq. in, per 100 lb. weight of car. For 3000-lb. cars a value of 5.7 sq. in. per 100 lb. car weight is given. This is approximately equivalent to saying that for each 16 lb. of car weight a square inch of surface must be provided.

P. M. Heldt, "The Gasolene Automobile," Vol. II, p. 313, gives the following recommendations:

Passenger Cars, Hub brakes	1 sq. in. per 15 lb. car wt.
Passenger Cars, Transmission brakes..	1 sq. in. per 30 lb. car wt.
Commercial Cars, Hub brakes........	1 sq. in. per 30 lb. car wt.
Commercial Cars, Jack-shaft brakes...	1 sq. in. per 85 lb. car wt.
Commercial Cars, Transmis'n brakes..	1 sq. in. per 175 lb. car wt.

In the case of commercial vehicles, the foregoing recommendations are based on a jack-shaft speed intermediate between engine and rear wheel speeds, and a transmission brake at engine

speed. Data taken from several passenger cars show values as high as 22 lb. loaded car weight per sq. in. of lining.

SUMMARY:

In the foregoing the fundamental equation expressing the relation between braking resistance, kinetic energy and distance to stop, has been developed. The main factors composing braking resistance have been discussed and related to the fundamental equation. Typical brake mechanisms have been analyzed and a detailed application has been shown for an external contracting band brake of the usual form. The results of this analysis have been compared with the fundamental conception of braking resistance and with the result of an actual test on the particular brake mechanism in question. The effect of rear axle gear ratio on transmission brakes has been considered. Internal expanding brakes have been briefly discussed. Finally the relations between brake lining areas and car weights as recommended by various authorities and as used in practice have been given.

NATIONAL BUILDING CODE

Secretary of Commerce Hoover recently announced his decision to develop a national building code to govern the design and construction of buildings. With this idea in view, he has appointed a committee of seven well-known engineers and architects to prepare a standard code.

This committee, acting under the direction of the Department of Commerce, will be charged with a great responsibility, but it will have an excellent opportunity to standardize building materials and methods of design and construction. With these objectives accomplished buildings of the future will be fire-resistive to a much higher degree than at present. They will require less labor and material in their construction and will therefore be more economical in the use of both.—American Builder, Oct., 1921.

PAST, PRESENT AND FUTURE TRENDS IN MOTOR CAR DESIGN

By F. E. MOSKOVICS
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PAST

Owing to the vastly different road conditions in this country and in Europe, there is a vital difference in the engineering requirements of present-day designs in American and foreign cars to get the utmost efficiency and comfort.

In the early days of the art, however, American motor car design followed slavishly the trend of Europe's lead. At that time, the great problem was not efficiency or comfort, but to make a machine run. Reliability was measured in terms of whether a machine would run an hour or not. As Europe had hewed the early path and as we had to learn to creep first, we followed that path of least resistance even to the byways of the foreign designer's early mistakes. One of the most flagrant of these was the lack of relationship in the design of body and the design of the mechanical part or chassis. All the early builders in Europe, prominent among these being Mercedes, Panhard, Levassior and Renault—all were what were known as "mechanical constructeurs," and they would have thought it beneath their dignity to deal with wood and leather, and as soon as they finished the chassis, it was immediately taken to one of the great Parisian coach builders with instructions to build a body. Now, all he was told was that the vehicle should carry five passengers and that its speed was from 50 to 80 km. per hour. He was not even informed that the designer of the chassis had built his structure sufficiently strong to carry five passengers, so he in turn designed a body to carry these passengers at the designated speed, the result being that from a purely structural standpoint, the completed car was easily capable of carrying twice the number of passengers for which it was originally designed. So, through this lack of co-operation in construction, there was considerable waste of weight and many parasitic parts. This, I firmly believe, was the most pronounced early error.

It was only when the industry developed on this side strongly

enough to throw off the shackles of Europe that we awoke to right thinking along these lines. Of course, one of the strongest elements in this was the fact that with all the large factories in this country, the body and chassis are designed and quite often built by the same organization. Thus, the product is a well related whole.

In the early motor cars, the question of light weight was never even discussed. In fact, many engineers boasted of the heavy weight of their cars as directly responsible for ease of riding. Today, we have discovered the real fundamentals that underlie ease of riding, and I shall speak of that subject in analyzing the present trend.

In the early motors, flexibility of engine design was unknown. The inflexible 4-cylinder type with the heavy fly-wheel and inflexible carburetor was the dominating type. It was known even in those days, however, that this motor, due to its vertical unbalance, was not the ultimate type. Later, the 6-cylinder type was developed with its mechanically perfect crank-shaft design and its beautiful balance within reasonable speeds. Of course, cost was one of the factors to keep its application from being universal. I shall speak of the 6-cylinder type later in present-day designs. It is perhaps useless to go over the whole list of one, two, three-cylinder types and the 4-cylinder V-types because none of them ever attained any particular degree of prominence.

So it might well be said in summing up the early designs that little regard was given to weight; the motors were quite inflexible, often using 4-speed gear boxes to overcome lack of flexibility in the motor; efficiency was a thing unknown as designers were groping constantly to make a fairly reliable unit.

PRESENT

The present day motor car has overcome most of the errors of the early days. In varying classes, the engineers have developed light weight, highly efficient mechanisms. They have discovered that ease of riding is not a function of heavy weight but rather of properly balanced weight. They have discovered that there is a decided relationship between the weight above the springs, or the sprung weight, and the weight below the springs or the unsprung weight. They have discovered that the balance of weight between the front and rear wheels has a considerable

influence upon the riding effect. They have discovered that flexibility of motor design does not necessarily go hand in hand with large cylinder displacement. They have learned the simple lesson that weight in relation to work to be performed is a tremendously important factor. The result is that the present motor car, in addition to being beautiful in design, is highly efficient, extremely reliable with its high range of speeds and, in view of road conditions to be overcome, is a truly wonderful piece of mechanism.

The motors in the present day vehicle may be summed up under four heads—the 4, 6, 8, and 12-cylinder types. Each has its functions and it would indeed be a dangerous thing to attempt to prophecy the ultimate type.

It may be well, here, to point out a few general prevailing characteristics of each type. The 4-cylinder motor is perhaps best known to engineers as more technical data and experience has been gained from it. Its most important defect lies in the fact that the crankshaft is designed on a plane of 180 degrees and with each complete revolution of its shaft with its reciprocating parts, at normal speed a vertical unbalance of approximately 20 degrees of the stroke is the result. This, of course, manifests itself in hard pulling, and the motor is known as not being a "sweet" motor to drive.

We will jump from the subject of the 4-cylinder motor to the 8-cylinder for after all is said and done, the 8-cylinder is simply two 4's. When each set of cylinders is analyzed separately, it is obvious that the same vertical unbalance that is present in the 4-cylinder type is also present in each of the pair of 4-cylinders. Now, you can see that when these two unbalanced forces meet at the crankshaft, what the result will be. In the case of the 8-cylinder motor set at 90 degrees, there is a horizontal unbalance of approximately half the intensity of the single vertical unbalance of the 4-cylinder type. Many schemes have been devised in the attempt to overcome this defect, such as fitting up counter unbalances to cancel out this known unbalance, and bringing the cylinders closer together than an angle of 90 degrees to break up the parallelogram of forces formerly created. It is needless to point out that each of the schemes has certain drawbacks—that of irregular angle lying in the fact that you sacrifice uniformity of firing sequence to accomplish this. Notwithstanding these known factors, the 8-cylinder motor under certain condi-

tions is a very pleasant motor to drive, especially with a very low gear ratio at normal speeds, and because considerable power is concentrated in a short space owing to the very short crankshaft.

The 6-cylinder motor, having the throws of the crankshaft lying 120 degrees apart, is the best inherently balanced motor, and, in analysis, the 12-cylinder motor can be taken as two 6's, but without the attending complications of the 8 and 4-cylinder type, again due to the crankshaft relation. Within such limits of piston displacement that individual impulsations are not obnoxious (and engineers differ in this—for instance, Rolls-Royce has a 4½ inch bore where the other better English cars have 3½ inch bore) the 6-cylinder motor is a very satisfactory piece of mechanism to drive. Where care has been taken to obtain rigidity in the crankshaft so that the "periods" and "critical points" will develop at the higher motor speeds, above the operating range of the car, it is hard to improve upon the 6-cylinder at this moment. It is simple, very accessible, and with the present knowledge of carburetion, easy to handle from that standpoint.

I believe the outstanding feature of the present day science is the attempt to eliminate the parasitic or non-working parts, the attempt to reduce the mechanical losses through the entire mechanism, the attempt to put greater flexibility into the motor (in other words, greater range of engine performances without the intermediary use of the gear box); and higher efficiency both in fuel consumption and mechanics.

FUTURE

But for the future—ah, there indeed is the realm yet untouched! Notwithstanding the accomplishments of today, I firmly believe the next seven years will bring greater and better mechanical changes than the past seven years and that the thing that will bring about these changes is the art of road building.

Have you ever stopped to think that the problem of the automobile engineer in attempting to analyze the strains and stresses that his mechanism will undergo is a problem almost unparalleled in mechanical engineering. A mariner on his ship can clearly estimate the maximum stress of weight and water together with the changes of wind and weather; the locomotive engineer can

easily judge the ultimate stress when designing a locomotive—the grades and the loads to be hauled, the exact weather conditions to be encountered; the same can be said even of the designer of the airplane, and each and all of these can figure on their mechanisms being handled by experts. But think of the motor car engineer who is compelled to design a mechanism to be placed in inexpert hands, to be used under the most varying road conditions imaginable. The same mechanism must run smoothly over the magnificent highways of New York and Massachusetts at all speeds from 2 to 70 miles per hour and must overcome the horrible road conditions of Iowa, Missouri and Kansas and the altitudes of the Rocky Mountains, the snows of the North and the suns of the South, the sands of the desert and the salt of the ocean. All these things must be taken into consideration when the motor car engineer lays pencil to paper. With the advent of good roads—and this especially with reference to the great transcontinental highways when they become more than visionary dreams—the problems of the engineer become entirely changed. His work becomes more like that of the locomotive engineer and he can concentrate with more fixity of purpose, with greater uniformity of intellectual effort on the higher problems of making a gallon of gas do what two did before.

It might be said that today the art of motor car engineering is at about the stage that surgery was before the advent of the anesthetic. We knew anatomy then from the standpoint of the post-mortem, and we are just beginning to learn the actual anatomy of the motor car from a standpoint of operation. I shall venture a bold prophecy and although I know the usual fate of prophets, I won't even tremble—I predict the automobile of the future will be much lighter, will go infinitely further on fuel and rubber, and the improvement in clutches and motor design will make the speed change gear box practically an emergency tool; the riding will be infinitely easier and that 350 to 400 miles a day on our coming highways will be commonplace indeed.

THE SERVICE OF UNDERWRITERS' LABORATORIES

By B. E. Blanchard, Asst. Secretary, Underwriters' Association

"For Service—not Profit." This is the keystone of the arch symbolizing the activities of Underwriters' Laboratories in the work of reducing the enormous and disproportionate losses of life and property by fire. and the number of accidents in America.

The better to understand why steadily increasing demands are being made from year to year upon the facilities of this institution, a brief survey of its founding and growth is here given.

Twenty-five years ago a young electrical inspector of Boston came to Chicago as electrician of the Chicago Underwriters' Association to solve some problems in connection with automatic fire alarm service in Chicago and to inspect electrical installations at the World's Fair. He suggested the idea of a laboratory for testing electrical devices met with in the field. The result was the modest beginning of Underwriters' Laboratories, then called the Underwriters' Electrical Bureau, with a bench, a table, some electrical measuring instruments, and a few chairs, the location being on the third floor of Fire Insurance Patrol Station No. 1 on Monroe Street, Chicago. The electrical testing work then turned out, together with reports of electrical fires began to attract attention outside of the central west, secured the aid of the National Board of Fire Underwriters and the name was changed to the Electrical Bureau of the National Board. Gradually work was extended to cover the whole field of fire protection and fire prevention engineering and with this greater scope demands increased and larger quarters were obtained. A building which had been used as a boys' school on Twenty-first Street, Chicago, was moved into and seemed too large.

In November, 1901, Underwriters' Laboratories was incorporated under the laws of Illinois, the state granting a charter "to establish and maintain laboratories for the examination and testing of appliances and devices, and to enter into contracts with owners and manufacturers of such appliances and devices, respecting the recommendation thereof to insurance organizations."

Besides the work in electricity, good progress was now made with acetylene, gasoline, automatic sprinklers, hand fire extinguishers, fire-doors and fire-windows. The work in this widening field won the complete support of the National Board of Fire Underwriters and a general appropriation from that body to be used in the upbuilding of the institution, this relation continuing to the present time.

In 1904, the schoolhouse became too small and as a result the erection in that year of a model fire-proof building at 207 E. Ohio Street, followed and here are located the principal offices and testing station. Offices and agencies are located throughout the United States and Canada.

The New York office is equipped for the conduct of examiners and tests of all electrical devices under the same condition as those afforded at the principal office and testing station in Chicago.

The Chicago plant occupies a three-story and basement building of fire resistive construction. Yard space is provided for large testing furnaces. The main building in Chicago is, perhaps, the best example in America of fire resistive construction furnished with fire resistive finish and equipment and operating properly safeguarded machinery. Brick, terracotta, concrete, stone, steel and iron are used exclusively in the structural features. The window frames and sash are of metal with wired glass, the doors are of glass, the desks and filing-cases in the main office are of steel. No wood or other combustible material is used in any portion of the finish. In addition, the plant is equipped with automatic sprinklers, and the machines, appurtenances, and lighting, heating and power hazards are safeguarded with every known precaution. In this model building the Underwriters have gone to the extreme in adopting in their own property all the measures they are known to recommend in the property of others. Over one hundred and thirty persons are employed in the Chicago plant, which, with its equipment, has a value of approximately $225,000.

Underwriters' Laboratories is engaged in the unusual business of serving, by endeavoring to tell other people things that are necessary and beneficial for them to know in connection with their business, where it touches the fire, life and accident hazards.

A statement of opinion upon any subject is of no lasting value

unless correct. A hundred authorities may subscribe to a statement and as many powers seek to enforce a ruling based thereon. If the statement is fundamentally wrong, it cannot prevail. Paraphrased, David Crockett's remark, "Be sure you are right before you go ahead," sets forth the reason for the success of Underwriters' Laboratories' service.

There can be but one best opinion with regard to the merits or demerits of any device, system or material in its relation to fire, life or accident hazards. Manufacturers, buyers, users, engineers, experimenters and observers all form opinions and often these are widely at variance, but among them all there is to be found somewhere a consensus that is correct. And it is just as the Laboratories is able to work this out and promulgate the correct concensus of opinion, that it is able to render service to the best advantage to clients, to users, to the insurance companies and to their customers, the assured.

So far as possible, it is the practice of Underwriters' Laboratories to make its work constructive. No attempt is made to fill the place of the engineer who designs some device or system, but it is the custom, where it seems practicable, to advise the manufacturer submitting a product, how safeguards proved to be necessary can be economically secured.

A problem of insurance interests is to obtain in the installed products of various industries a reasonable degree of safety as to fire or accident hazard in an economical way. Any institution attempting to impose conditions that are needlessly burdensome upon any product would fail to secure the best measure of safety. The Laboratories seek to obtain reasonable safeguards if possible, without imposing a burden upon the manufacturer or upon the industry.

One of the initial steps was to find a means whereby the industries served might profit directly from the counsel and good judgment of men having extensive experience in the fields where the devices and material that come before the Laboratories are to be used. It is believed that men having this experience are best qualified to form correct conclusions from the data secured in laboratory tests.

This belief led to the formation of Underwriters' Laboratories' Councils of which there are four: The Fire Council, The Electrical Council, the Casualty Council and the Automobile Council.

These councils are made up of men who are authorities in their chosen line, men who represent various interests, and among whom are representatives of the Federal Government. To the Fire Council are referred questions of fire hazard; the Electrical Council passes upon matters relating to the use of electricity for light, heat and power, the Casualty Council is asked to pass upon the recommendations of Laboratories' engineers concerning the casualty features of products submitted, and the Automobile Council performs a like service in the automobile field, covering fire and casualty features. The service which these councils' members are so freely giving through the Laboratories is unquestionably of great value to the industries concerned and to the public, and it is difficult to see how it could be provided through any other channel.

As a further factor in service rendering are the Laboratories' Industry Conferences. For a number of industries, conferences are established consisting of the proper members of the staff of the Laboratories and representative committees of manufacturers, to the end that full information as to examination and test methods may be transmitted to industries served by the Laboratories' system of inspections at factories and the labeling of products, and the views of the industry as a whole on these items be secured. This unity eliminates duplication of effort.

With the completion of the examination and test of a product a report in the form of data and conclusions is forwarded for review to the proper Council. As already indicated, Underwriters' Laboratories is much more than a testing station for sample wares, and, in case of endorsement of a product by Council and a listing as standard, a practicable, efficient system of follow-up is essential for providing comprehensive information concerning the factory output and its behavior under conditions of actual service.

A laboratory test on a sample material cannot of itself usually be depended upon as a reliable criterion of the quality of the daily output of the factory. Test work that ends when tests on a sample material have been completed is necessarily of limited value; hence the importance of proper check methods on a run of goods is obvious. Years of study by Underwriters' Laboratories of this problem of securing quality maintenance led to the establishment of its Label Service.

When the product of a manufacturer is admitted to the Label Service, following suitable investigation of sample goods, inspection is established in the factory. Inspectors and engineers in the employ of the Laboratories follow the daily run of material through various processes of production and conduct such tests as have been specified and to goods thus found to be of suitable quality, Underwriters' Laboratories labels are attached. Check-tests that cannot be conveniently made at the factory are made on samples forwarded by the inspector to headquarters. This service is further reinforced by tests on labeled material purchased from dealers and on samples of labeled product taken out of service and sent in from the field. Thus, for a large class of products the label on the goods tells the architect, the engineer, the contractor, the inspector, the builder and the property owner that the product has been inspected and passed.

Experience has shown that the labeling method is in every way superior for the purpose of bringing to the consumer the article he desires, for the purpose of placing competition between manufacturers beyond the point where deterioration in the quality of the output is made necessary, and for the proper protection of the Laboratories and the organizations co-operating with them and giving substantial recognition to efficient protection appliances.

A brief review of some of the more important activities in various departments for the year 1920 affords a means of surveying the scope of the Laboratories' Service.

PROTECTION DEPARTMENT

The year has been filled with the usual work in the fire retardant and fire extinguisher groups. The outstanding fact for the period, however, is the interest in methods of incorporation, in buildings of frame and ordinary construction, of features which enable them to develop a higher degree of fire resistance than has heretofore been typical of these types and to these considerable attention has been given.

The opportunities in this direction will be appreciated when it is known that our investigations show that the fire resistance of wood, lath and plaster finish of average construction is about five minutes after the fire has reached the stage where the contents of the building are thoroughly involved, and that the fire

resistance of the substitute for lath and plaster most commonly employed is less than two minutes under the same conditions. This in addition to the fact that the latter finish also serves to convey fire rapidly to all parts of the building in which it is used. Including exterior wall finishes, the work on these building items has already included the investigation of some eight or ten types of construction differing widely in character and in the degree of fire protection furnished. On account of their employment in buildings of studded and joint construction, it has been necessary to include the study of the methods of fire stopping in hollow walls and ceilings. The accurate classification of the items already investigated in terms of period of fire resistance will probably be available during the coming year, possibly within the next few months. The gradual extension of such classifications to include various other forms of construction now on the market should afford means of accomplishing very marked results in fire prevention work.

Work on roof coverings has continued as heretofore, and, in addition, methods have been developed for the more accurate determination of the spark and flying brand hazard involved in the more inflammable forms of roof coverings.

The necessity for the investigation of the larger subjects has never been lost sight of and plans are constantly being extended to include such subjects as the larger items of building construction and the more elaborate extinguishing systems. Some idea of the magnitude of such developments may be gained by a study of the column test plant and its auxiliary equipment now in use at the Laboratories. In a report recently issued are presented the results of the tests of over one hundred structural building columns, an investigation made jointly with the Mutual Companies and the Bureau of Standards.

The fire resistance of floors is another highly important subject now receiving active attention.

HYDRAULIC DIVISION (Protection Department)

Work of this Division has been confined mainly to the usual run of devices, such as automatic sprinklers, dry pipe valves, alarm valves and other sprinkler system devices.

In December the hydraulic laboratory was the scene of an interesting investigation relating to breakage of dry pipe valves in the field.

In 1920 approximately 3,500 old sprinklers were sent in from the field for test, in lots ranging from 2 to 24, and the usual reports covering the reliability of sprinklers in the equipments from which these samples were taken were rendered, copies of the reports being furnished the assured, the interested inspection departments and the sprinkler companies concerned.

GASES AND OILS DEPARTMENT

The activities of the Gases and Oils Deparement have been confined largely to the examination and test of the usual run of appliances, such as gasoline, discharge devices, hand fire extinguishers, dry cleaning apparatus, fuel oil burning devices, fuel oil engines, farm lighting plants, acetylene generators, etc.

Numerous fuel oil burners for domestic use were submitted for examination and test and it is expected that the list of appliances of this class will be greatly increased during the coming year.

ELECTRICAL DEPARTMENT

The work of the Electrical Department has been divided between the main office in Chicago and the electrical testing station of the New York office as heretofore, approximately half of the new tests and investigations being conducted in each place. The year has not been marked by any radical changes either in standards for appliances or in the general types of devices under investigation.

The Laboratories' Standard for Non-Metallic Tubing has been revised and improved. New standards have been issued on asbestos-covered heater cords and on varnished cloth insulated wires and cables, and numerous minor changes have been made in other electrical standards. All of this work on such standards has been done as always, in close co-operation with the industries affected and through the several Industry Conferences.

A large amount of test work on fuses especially of the renewable type, has been done both in Chicago and New York. At the latter place a total of over 6,700 cartridge fuses of all sizes and types have been tested for short-circuit performance at the well equipped fuse test station at Kingsbridge. A large number have also been tested in Chicago.

CASUALTY DEPARTMENT

The expansion of the Casualty Department during 1920 was due largely to the adoption of the merit system of rating automobiles from the fire hazard viewpoint by the National Automobile Underwriters' Conference. As a result of this action, Underwriters' Laboratories' Schedule for the Classification of Automobiles was put into practical use and passenger automobiles and commercial trucks of a number of manufacturers were formally submitted for examination and classification. These reports contemplated not only a measure of the fire hazard of the device, but also means of re-designing the device, or improvements in construction methods, which, if utilized, would result in a reduction in the inherent fire hazard.

Recognition by the automobile insurance companies of the value of bumpers in reducing collision losses resulted in the submittal for test of bumpers from all the leading manufacturers, and over 500 bumpers were subjected to the standard test and the results reported to the companies.

Reports on numerous devices employed as standard equipment on automobiles were issued, including reports on vacuum tanks, carburetors, ammeters, gasolene gauges, overload circuit protectors, radiator guards, gasolene fittings, rear warning signals, explosion whistles, etc.

The routine work on automatic locking devices, spare tire locking devices, motorcycle locking devices and motometer locking devices was continued, the standards for tests being much higher than previously, with a marked increase in the number of appliances tested and listed.

Tests of accident prevention devices, such as material for machine guards, metal and wood working guarding appliances, ladders and goggles received well merited attention and indicated a growing interest in this department of the work on the part of the manufacturers.

As a result of marked interest on the part of manufacturers of burglary appliances, the department is at the present time devoting considerable effort to the development of standards and of test methods for the investigation of the theft-resisting qualities of safes and safe deposit boxes, as well as the value from a burglary viewpoint of burglar alarms, burglar locks, bullet-proof glass, etc.

CHEMICAL DEPARTMENT

The Chemical Department's volume of routine chemical and physical tests on labeled insulated wire, fire hose, roofing and rigid conduit showed an increase. Tests under various specifications on wire and hose for municipal authorities reflected a more widespread interest in our service. Investigations of present standards on wire and hose were undertaken, having for their object progressive improvements based on experience and development. Working with other departments, a new Heater Cord Standard was developed.

The volume of tests for classification of hazards of cleaning fluids, polishes, sweeping compounds and floor oils showed a continued growth. The work on gasolene hose, fire hose couplings, motion-picture films, matches, protective coatings (zinc), and the determination of the properties of metals used for extinguishers, continued to increase. Tests for other departments along specialized lines were made in much larger volume than heretofore, particularly pyrometry. At present the preparation and calibration of thermocouples for measuring high temperatures is being done for other departments.

The department was called upon to perform special work in answering inquiries on various technical subjects for boards, bureaus and industrial concerns. This included, particularly, questions relating to the hazards of various chemicals, processes of manufacture, propagation of explosions, and spontaneous ignition.

An extensive investigation on the corrosive action and nature of the products formed when carbon tetrachloride extinguisher liquids are applied to fires was undertaken and the results presented in the January, 1921, Quarterly of the N. F. P. A. An investigation of the hazard of ammonium nitrate was conducted for the American Cyanamid Company. An investigation was conducted for the Gas Products Association to ascertain whether the high pressure under which hydrogen and oxygen is transported for use in the industries changed the explosive limits as found for these gases under low pressures. The result was published in the February number of a technical magazine. Two other investigations are now under way, one on formation of sulphuric acid in rubber-lined fire hose on standing, and the other on the

hazard of hemp (which has recently caused several million-dollar fires) and its tendency to ignite spontaneously.

ELECTROLYTIC OXYGEN AND HYDROGEN WORK

During 1920 preliminary inspections of sixteen electrolytic plants were made and reports issued, based on the detailed application of our present Standards, to the plant management, pointing out the line along which the equipment and operating methods should be changed in order to bring the plants into conformity with the Standards and thereby make it possible for periodic Inspection Service to be established. Three of these plants were reinspected after some of the difficulties had been overcome. The active work of making these preliminary inspections began about May, 1919, and up to date there have been a total of twenty-five plants inspected and reported upon in the usual manner. A number of other plants have been informally examined during the year.

In addition to the inspection of plants with a view towards the establishment of Inspection Service, we have also been called upon to make several special inspections and investigations. Early in 1920 a detailed inspection and report on the electrolytic oxygen and hydrogen plant as well as on the acetylene compressing plant at the Boston Navy Yard were made.

LABEL SERVICE DEPARTMENT

The Label Service has grown in its popularity to where the average number of labels used has been somewhat in excess of 1,000,000 per day. During the first ten months it was a problem to keep sufficient stocks of labels on hand. Deliveries were slow and workmanship poor, but fortunately the critical period was passed without subscribers being put to serious inconvenience.

The service during the year has been extended to include the labeling of the following list of products and appliances: anti-freeze extinguishers, electrolytic hydrogen and oxygen, gypsum wallboard, heating pads, heater cord, motorcycle locks, 1½-quart pump type fire extinguisher, renewable cartridge enclosed fuses, safety cleaning fluids, solution for treating cotton, spare tire locks, treaded cotton bales and varnished cloth cables.

THE GREATER CONTEST

B. E. SUNNY

President, Illinois Bell Telephone Company

The athletic contests that are so much a part of school and college life appeal to every normal boy beyond anything else, and his greatest ambition is to excel at his chosen sport and be one of the stars. If he cannot get into the game, he nevertheless is an enthusiastic rooter for his team. The spirit of contest is in all of us in varying degrees. There are unlimited opportunities for its full exercise.

The classroom is the arena when the athletic season is closed, and the spirit of contest—the desire to succeed—has always inspired unusual effort and has made many winners.

Later, when we have finished college and gone into business, the chances of success are determined materially by the amount of the spirit of contest that we have still left in us, and whether we use it wisely. We are of course dealing with the subject in its best sense, not physical encounter, but a determination to get definite and worth while results, in the pursuit of which physical opposition by our fellow-men may be our smallest obstacle. We are baffled in most projects by the inherent difficulties, and too often by our own lack of application and perseverance.

But the spirit of contest in us, even in those who are most generously endowed, is frequently applied to one purpose—personal advantage and success. There is a greater and more inspiring ideal which carries with it personal success, and puts us squarely into that greatest of all games—keeping the world moving forward.

Men are the "Heirs of all the Ages." The legacy is richer with every generation because of the genius and industry of the millions who have preceded. In our early history the gift of the ages was largely hardships and privations. These have now mostly disappeared, crowded out by innumerable comforts

and conveniences. A hundred years from now, if we live up to our obligations, the world will be still finer and richer; wars may be impossible; disease and crime reduced; the destruction of life and property by fire and flood eliminated.

With our proprietary interest in all the world, in the rights, privileges and pleasures we every day enjoy, we become trustees, not only to support and maintain the great enterprise as we find it, but to add to it. That is where the broader play for the spirit of contest comes in. There is in the fact of our existence a challenge to push the world forward. We have all succeeded someone, and in time we in turn will ourselves be succeeded by others.

The last two generations have set a swift and unprecedented pace in accomplishment; the automobile; aeroplane; telephone; wireless telegraph and telephone; typewriter; electric light; passenger elevators, etc., with corresponding remarkable achievements in the arts and professions. Our task is heavier than any heretofore borne by man; for we are the custodians of the accumulated experience and knowledge of the world. We must guard the great treasure; use it wisely and add to it as becomes the period in which we live.

It would be an exceedingly disastrous experience to engage in if we all, at say twenty years of age, called "time" in our contest for self and world advancement, and for twenty-five years or so drifted with the current of life in purposeless and aimless fashion. The people who are keeping the world going would have passed away, and we, the "Heirs of all the Ages," having frittered away the best twenty-five years of our lives, would be incapable of assuming or carrying our responsibilities.

While we would still have the products of the toil and skill of our predecessors, and the books and records descriptive of all that had been achieved, which we could read but not understand, the continuity of the scheme of human endeavor would be broken.

Our share in the benefits and burdens of the world has come to us from countless generations. We cannot be deprived of the one or relieved of the other. But the burden after all is a privilege; an opportunity to match our mental and physical strength.

our vision and courage, our humanity and patriotism against that of the men of whose names we now stand in awe, but whose places we must some day fill. The contest is to accomplish more than they. If we succeed we shall have won personal success, because we cannot add to the riches of the world without enriching ourselves at the same time.

SWELLED HEAD

Not all cases of "swelled head" are bumptious and offensive. Many men contract this dangerous disease without knowing it. It is very agreeable to its victim, it soothes and satisfies him. It has numerous subtle forms which should be learned and rigidly avoided. Some people get it by winning promotion; they think the promotion is a decoration pinned on, instead of a challenge to carry heavier burdens and fulfill more exacting demands. You don't measure success on arrival, but on leaving. Arrival is only opportunity, it is not achievement. People with "swelled head" think it is achievement, and in the end the delusion destroys them. A sense of proportion cannot be preserved by comparing yourself with yourself.—Dearborn Independent.

The Armour Engineer

The Quarterly Technical Publication of the

Armour Institute of Technology

VOLUME XIII NOVEMBER, 1921 NO. 1

Published four times a year, in November, January, March and May. Publication Office: Federal and 33rd Streets, Chicago.

TERMS OF SUBSCRIPTION.

The Armour Engineer, four issues, postage prepaid, $1.50 per annum

VOL. XIII.—NO. 1.

This issue of "The Armour Engineer" marks the thirteenth year of its publication. The staff, refusing to acknowledge the implied significance of the figure, is looking forward to a year which will be marked by the maintaining of the "Engineer" up to its standards of the past, and its improvement if possible; and also a year which will be one of decided forward movement in the affairs and organization of the alumni association.

We know the "Engineer" has a right to exist, based upon

its primary purpose—the recording of the accomplishments of Armour alumni and of the events in the progress of the school. That right to exist will not cease until the Armour alumnus has ceased to do things worth recording, and that will be—but why anticipate the inevitable signal of Gabriel.

It remains for us, and we recognize the responsibility, by all the means in our power to ferret out the accounts of these deeds of those who went before us. The difficulty we may have in so doing, we ascribe to the inherent modesty of the engineer in general, and that of the real Armour man in particular. But we would remain just as satisfied if he would overcome some of this precious trait of character and voluntarily give us the assistance he knows we need.

The ideal state of affairs would be where the Editor was merely a sort of clearing-house, his job that of sorting out the most desirable of the contributions which were pouring in on him in every mail. The loss in this case would be on the part of the Editor in not coming into direct contact with the men whom he does meet when "chasing" articles. Towards the end suggested and till that time comes, we will work to the best that is in us.

THE STAFF.

WHEN YOU GET A GOOD THING, REMEMBER WHERE YOU GOT IT

Doubtless most of the Armour grads still believe that when they graduated they had "gotten a good thing," if the knowledge gained or the ability to acquire knowledge may be so classified. But do they remember the place where they got it? Yes, if you think of remembering as merely recalling to memory at times. But such actual advantages as those they did get and at a personal cost not at all commensurate with actual expense involved, should be remembered in a more concrete manner.

And how may this be done? By supporting the alumni association and its projects, by supporting the "ENGINEER" with subscriptions and articles, and by dropping in at the Institute once in a while, and in other ways which may come up and be discernible only to yourself.

Concerning the matter of dropping in at the school. We all know that the monetary considerations given professors are not always in proportion to the work they do, for if they were, education would indeed be financially beyond the reach of all but a few of the inhabitants of our planet. But, the true teacher is one who finds satisfaction in helping someone, who, because of this help, may be led to accomplishments that are a credit to himself and of benefit to society as a whole. Therefore you owe it to your professors to let them know how you are progressing.

Perhaps those who most need to be reminded of the facts outlined will never see this publication, but each one who does see it should consider himself a committee of one to spread the gospel. If each of us would feel a little individual responsibility, much could be accomplished.

INCREASING OPPORTUNITIES FOR ENGINEERS

A study of modern economic conditions reveals the rather interesting fact that engineers as a class have been and are extending their field of operations. There are, perhaps, two fundamental reasons for this. One is due to a somewhat crowded condition in the purely technical field and the other is the inducement offered in somewhat related lines combined with the readiness with which a well trained engineer can adapt himself to varying environment.

The engineer as a salesman of engineering devices has long ago demonstrated his value. As an executive, he has shown that he can manage men in industrial organizations as well as machines. As a banker, he has found that he can call his work "Financial Engineering," thus making it seem less remote from his original ideas of his profession, and make a success of it.

In all of these ventures, the engineer has kept in mind the fundamental ideals of his type, the accomplishing of a result in the most economical manner possible. This is one reason why we have had a committee of engineers investigating the general problem of national waste.

Using the political economist classification to separate our

activities into those connected with the production of wealth and those connected with its distribution, we find there is more room for improvement in the economics of distribution than of production, yet we hear more about production engineers than we do about distribution engineers. And herein lies an immense field for the application of engineering talent.

It is true that engineers have worked on distribution problems, but such problems have dealt mainly with the mechanics of distribution. Now the mechanics of distribution have been immensely developed just as have the mechanics of production, but these features constitute only a part of the total problem of economic distribution. Capital, labor, and the public must also be considered. The engineer has been studying these things but the proceedings of our national engineering societies show that he has interested himself in them to a very limited extent only. Yet they are so closely connected with the machinery of distribution that he may well consider them within his field of activity. He can if he will. He has the type of mind and the ability to produce improvements where improvements are most needed.

E. H. Freeman.

THE TRIBUTE OF THE UNDERWRITERS

In the main corridor of the Institute Main Building is now to be found a new testimony of the farsightedness of our late President, Dr. Frank Wakely Gunsaulus, and symbolic of his educational activity. A photographic reproduction is to be found in this issue of the "Engineer." The speeches of presentation and acceptance are reproduced here. The presentation occurred at the 50th Annual Meeting of the Fire Underwriters' Association of the Northwest, the speech of presentation being made by Wellington R. Townley, ex-President of the organization and a close friend of Dr. Gunsaulus, while Acting President Howard M. Raymond accepted the tablet on behalf of the school.

Mr. President, Members of the Fire Underwriters' Association of the Northwest, and our Honored Guests:

At the opening of this afternoon's session, we have set aside a few minutes for the unveiling and presentation of this tablet.

It is appropriate that we, as insurance men, commemorate the passing of Doctor Frank Wakely Gunsaulus, preacher, educator, art lover, citizen, and friend. Seldom is it our privilege to gain for our business the interest of great men whose principal activities are outside the profession of fire insurance. Dr. Gunsaulus was a man who rose to every occasion and never failed to do the worthy thing. When we approached him regarding our modest little scholarship at Armour Institute, he received the intelligence of our proposal as enthusiastically as though it were some great benefaction to that institution. His friendliness alone gave the project prominence and we today are happy to record the presence of over fifty students at Armour Institute preparing themselves for the great work of conserving life, property, and all their essential values.

It is not my purpose to attempt any eulogy of this great man. Memorial meetings without number have been held in this city and elsewhere in which his power as a preacher; his influence as an educator; his help to all the branches of art; his value as a citizen, have been faithfully and lovingly recorded. We wish simply and modestly to claim him as part of ourselves. His honorary membership in this Association is something that we shall always cherish. Do you remember his last words to us? They sound today like a benediction:—"You are drilling soldiers in a crusade against waste, in behalf of the home, the factory, the workshop, the temple of Almighty God. And may God give you grace to measure up to the opportunities of your time and generation."

The very day the spirit of Dr. Gunsaulus returned to the God who gave it, a few of his friends in the Fire Insurance business, representing its many branches, local and national, met and decided that some fitting memorial should be adopted and this tablet was the result. Mr. George Ganiere, the Artist Sculptor, knew the Doctor well; they met very often at the Art Institute, and the wonderful likeness the artist has given us adds greatly to the value of our memorial.

Our Committee has consulted with the authorities at Armour Institute and we have selected a place where the tablet will be placed. It is just outside the door of the office which Dr. Gunsaulus, as President of the Institute, occupied for so many years. And when the new buildings are constructed, we are assured that

our gift will find a prominent and permanent place where the record of our appreciation of this great soul will be perpetuated.

We have as honored guests with us today the Deans of the Institute, one of whom is now Acting President, and I shall therefore ask Dean Raymond, on behalf of Armour Institute of Technology, to accept this gift from the various fire insurance organizations, whose names appear on the tablet. The memorial carries with it our love for our friend and the assurance of our continued interest in the welfare of the institution to which he was so devotedly attached.

WELLINGTON R. TOWNLEY.

Mr. Chairman, and Gentlemen:

On behalf of the Board of Trustees, I receive this tablet with true regard to its importance, not only to the Armour Institute of Technology but to the field of education in America. Eloquent tributes have been paid to Dr. Gunsaulus as a preacher, orator, lecturer, citizen, art lover, and educator, but this tablet, as a lasting and appropriate memorial, justly celebrates a great and distinguished man as a pioneer in the establishment of a special branch of engineering education.

In 1903, Dr. Gunsaulus, after several conferences with the President of the Underwriters Laboratories and other prominent officials, who were interested in the prevention of fire and the appalling destruction which follows in its wake, decided to establish a four-year course in Fire Protection Engineering at the Armour Institute of Technology.

In common with many new ventures in education, it was received with some misgivings regarding its stability as a distinctive branch of engineering and, consequently, passed through a period of years of quiescence and some uncertainty, but Dr. Gunsaulus, with his far-sighted vision and enthusiasm, was always optimistic, and his public utterances in behalf of fire prevention, always so impressive, wielded a mighty influence in the sweeping away of feelings of apprehension.

The Western Actuarial Bureau, in establishing a scholarship fund for the benefit of students in Fire Protection Engineering, has performed a most magnanimous service. Dr. Gunsaulus has often spoken of his great appreciation of the loyal co-operation of the Underwriters Laboratories, and now with these scholar-

ships available for earnest and capable young men, the future and success of the course in Fire Protection Engineering is assured.

The organization whose names appear here have dedicated this splendid gift to the noble memory of a noble man, whose life was a series of noble acts for the betterment of his fellowmen. This tablet will always be held as a sacred trust and occupy a prominent place in the buildings of the Armour Institute of Technology, whether old or new, where all may see; where the young may be impressed and inspired by the record of a worthy act of their former President, and the old will breathe the spirit of a great benefactor in the cause of education.

HOWARD M. RAYMOND.

THE GOAL IS WON BY WORK

The diamond's best rays
  Flash from the carved stone;
So genius wins praise
  By labor alone.
The hand on the dial
  Goes ceaselessly round,
And the ultimate goal
  By the worker is found.

A fluid takes shape
  Of the vessel that holds is;
A soul, too, is formed
  Of all that enfolds it.
Choose therefore thy friends
  'Mid the learned and wise,
That straining to them
  Thyself thou mayst rise.

Haruko.

The House by the Side of the Road.

There are hermit souls that live withdrawn
In the place of their self-content;
There are souls, like stars, that dwell apart
In a fellowless firmament;
There are pioneer souls that blaze a path
Where highways never ran.
Let me live in a house by the side of the road
And be a friend to man.

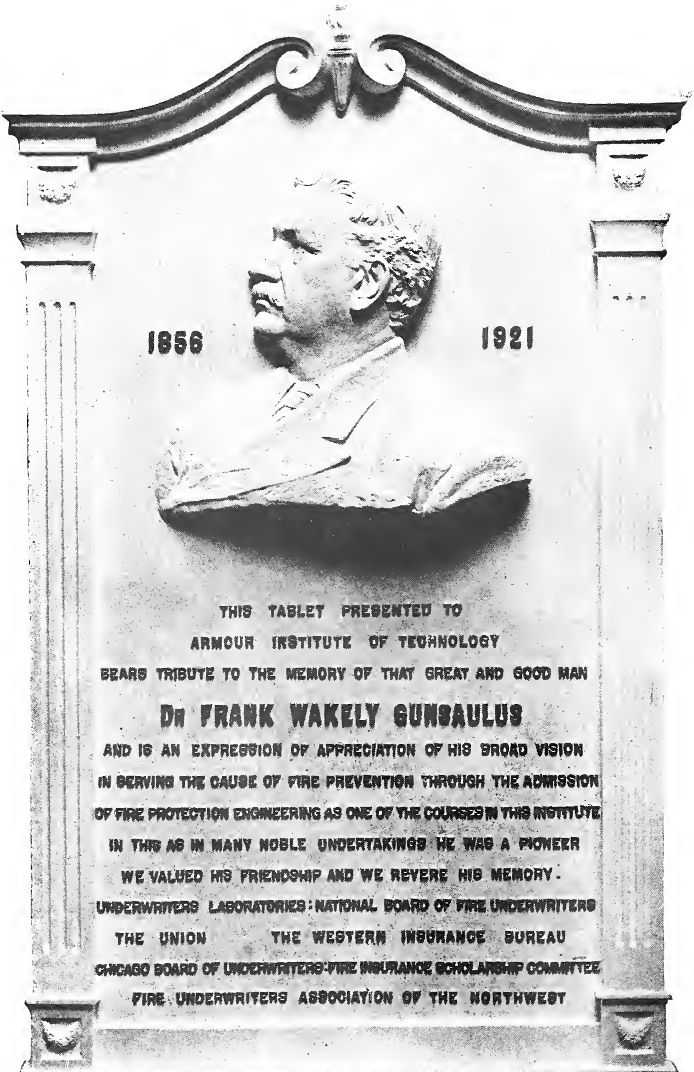
Let me live in a house by the side of the road,
Where the race of men go by—
The men that are good, the men that are bad,
As good and as bad as I.
Then why should I sit in the scorner's seat,
Or hurl the cynic's ban?
Let me live in a house by the side of the road
And be a friend to man.

I see from my house by the side of the road,
By the side of the highway of life,
The men that press on with the ardor of hope,
And the men that are faint with the strife.
And I turn not away from their smiles and their tears—
Both part of an infinite plan.
Let me live in a house by the side of the road
And be a friend of man.

I know there are brook-gladdened meadows ahead,
 And mountains of wearisome height,
That the road stretches through the long afternoon
 And passes away to the night.
Yet still, I rejoice when the travelers rejoice,
 And weep with the strangers that moan;
Nor live in my house by the side of the road
 Like a man that lives alone.

Let me live in a house by the side of the road,
 Where the race of men go by.
They are good, they are bad, they are weak, they are strong—
 Wise, foolish; so am I.
Then why should I sit in the scorner's seat
 Or hurl a cynic's ban?
Let me live in a house by the side of the road
 And be a friend to man.

—Sam Walter Foss.


1856
1921
THIS TABLET PRESENTED TO
ARMOUR INSTITUTE OF TECHNOLOGY
BEARS TRIBUTE TO THE MEMORY OF THAT GREAT AND GOOD MAN
DR FRANK WAKELY GUNSAULUS
AND IS AN EXPRESSION OF APPRECIATION OF HIS BROAD VISION
IN SERVING THE CAUSE OF FIRE PREVENTION THROUGH THE ADMISSION
OF FIRE PROTECTION ENGINEERING AS ONE OF THE COURSES IN THIS INSTITUTE
IN THIS AS IN MANY NOBLE UNDERTAKINGS HE WAS A PIONEER
WE VALUED HIS FRIENDSHIP AND WE REVERE HIS MEMORY.
UNDERWRITERS LABORATORIES: NATIONAL BOARD OF FIRE UNDERWRITERS
THE UNION THE WESTERN INSURANCE BUREAU
CHICAGO BOARD OF UNDERWRITERS: FIRE INSURANCE SCHOLARSHIP COMMITTEE
FIRE UNDERWRITERS ASSOCIATION OF THE NORTHWEST

ENGINEERING SOCIETIES

THE ARMOUR INSTITUTE OF TECHNOLOGY BRANCH OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

Prof. G. F. Gebhardt............*Honorary Chairman*
Gilbert V. Bradbury......................*President*
Marvin R. Olsen...................*Vice-President*
Paul Rupprecht ....*Treasurer*
David S. Jennings.......................*Secretary*

The first meeting of the Mechanical Engineering Society for the year 1921-1922 was held in Machinery Hall on September 21. Professor Gebhardt gave an address in which he outlined the purpose of the organization. it being to train the members so that they will have the ability to talk before an audience in an easy and convincing manner. He pointed out the great value of such ability in almost any career that a man may follow.

The Society decided to hold the usual Annual Smoker on Friday evening, October 7, 1921.

On October 5, 1921, the second meeting of the Society was held. A very interesting and instructive talk on the manufacture of carbon dioxide for beverages purposes was given by Mr. Wittenmeier. Mr. Reihmer gave some of his experiences in clearing land with a one man stump puller, with illustrations.

The Annual Smoker was held Friday evening, October 7, in the Y. M. C. A. rooms, and was a complete success. The stellar feature of the evening was a hotly contested billiard match between Professor Gebhardt and Professor Perry. Running the

match a close second for the honors were the "eats" and "smokes" provided by the social committee consisting of Messrs. Wetherbee (chairman), Broad, and Pask.

Professor Gebhardt, the speaker of the evening, made clear to the student members the numerous benefits to be derived by active participation in the Society.

Professors Perry, Nachman, Huntley, Roesch and Swineford all responded with a few pointed remarks when called upon by the president.

On October 19 the third regular meeting of the A. S. M. E. took place in Machinery Hall. In compliance with a request from the parent organization, a committee consisting of Messrs. Walker (chairman), Kaye, and Rumely, was appointed to write a paper on "The Armour Conception of the Conduct of Student Branches." This paper is to be read at the winter meeting of the A. S. M. E. in New York City.

Mr. Erickson delivered a splendid talk on the "Lubrication of Steam Engines." He discussed the chief difficulties encountered and explained how these may be overcome.

The subject of Mr. Bursik's talk was "Oildag." This comparative new lubricant is a colloidal suspension in oil of finely divided graphite. The last three letters of Oildag are derived from the words defloculated Acheson graphite, Mr. Acheson being the originator of the mixture.

The Society has grown to such proportions that at this meeting the seating accommodations proved insufficient. Future meetings will undoubtedly be held in larger quarters.

The following schedule of meetings of the Society has been approved by the Dean's office:

Sept.	21	10:30 A.M.
Oct.	5	11:30 A.M.
	19	1:00 P.M.
Nov.	2	10:30 A.M.
	16	11:30 A.M.
	30	1:00 P.M.
Dec.	14	10:30 A.M.

Jan.	11	11:30 A.M.
	25	1:00 P.M.
Feb	8	10:30 A.M.
	22	11:30 A.M.
Mar.	8	1:00 P.M.
	22	10:30 A.M.
Apr.	5	11:30 A.M.
	19	1:00 P.M.
May	3	10:30 A.M.
	17	11:30 A.M.

The Mechanical Engineering Society has made an excellent start this year and is forging ahead in splendid fashion.

David S. Jennings.
Secretary.

LIST OF A. S. M. E. JR. MEETINGS FOR 1921-2

No.	Date	Day	Time	Room
1.	Oct. 7, 1921...	Friday	2:00 P.M.	Science Hall
2.	Oct. 26, 1921..	Wednesday	2:00 P.M.	Science Hall
3.	Nov. 11, 1921..	Friday	9:30 A.M.	Science Hall
4.	Dec. 1, 1921...	Thursday	2:00 P.M.	Science Hall
5.	Dec. 16, 1921..	Friday	10:30 A.M.	Science Hall
6.	Jan. 16, 1922..	Monday	2:00 P.M.	Science Hall
7.	Feb. 14, 1922..	Tuesday	2:00 P.M.	Science Hall
8.	Mar. 1, 1922...	Wednesday	2.00 P.M.	Science Hall
9.	Mar. 17, 1922..	Friday	9:30 A.M.	Science Hall
10.	Mar. 27, 1922..	Monday	2:00 P.M.	Science Hall
11.	Apr. 11, 1922..	Tuesday	2:00 P.M.	Science Hall
12.	Apr. 28, 1922..	Friday	10:30 A.M.	Science Hall
13.	May 11, 1922..	Thursday	2:00 P.M.	Science Hall

ARMOUR BRANCH, WESTERN SOCIETY OF ENGINEERS

Our organization has held two meetings and one smoker since the beginning of this school year. The attendance at all these occasions bespeaks a new interest in this important phase of our school life, the technical society.

At the first meeting of Prof. Phillips spoke briefly on the aims o fthe society for the coming year, and on the tendency shown in the department to make the Civil Engineering course a more general one, with very little specialization, the reason being that the aim of the training given is to make the men taking the same able to fit in anywhere. The need of today is service—the ability to fit in where needed.

Prof. Wells also made a few remarks on the history of the society at the Institute.

At our second meeting we were addressed by Mr. Edgar S. Nethercutt, Secretary of the Western Society of Engineers, on the subject, "The Organization of the Modern Technical Society." Mr. Nethercutt emphasized the fact that the local technical society should be a post-graduate course in study and it is the job of the young man to make it so. The local engineering society has its particular field as apart from that of the national organizations, in that it can be of more benefit to the community in which it is located. Its purpose lies in advancing the science of engineering and benefitting the profession. The society offers a rich opportunity to meet and make friends inside the profession.

It is the present intention of the society to hold its meetings at 11:30 every two weeks, and notices will be posted previous to the same. All Civil Engineering students are urged to be present and all others are invited.

The members of the W. S. E. and its friends are urged to attend at all possible opportunities the meetings of the parent organization held at the Lecture Hall, 1735 Monadnock Bldg., every Monday evening, at 7 o'clock, and also at various other occasions which may be determined by inquiring of the undersigned, who will endeavor to serve anyone interested. We particularly wish

to have it known that the W. S. E. is not confined to any specialty but embraces the entire field of engineering and holds meetings at various times in conjunction with the other engineering societies.

E. M. Seaberg, Sec'y.

ARMOUR RADIO ASSOCIATION

The first meeting of the Armour Radio Association for the year 1921-1922 was held on October 19, 1921, and was attended by fifteen radio men. The following officers were elected:

President	A. R. Mehrhof
Vice-President	H. I. Hultgren
Chief Operator	N. H. Reeves
Secretary-Treasurer	E. A. Goodnow

Mr. Mehrhof gave a short talk on the necessity of giving lectures in the radio club meetings and showed the benefits to be derived by the club as a whole and also by the individual speakers.

Professor Wilcox was then called on to set forth the purpose of the association to the new members. The A. R. A. is organized to maintain an interest in the science of radio and all matters relating thereto among those of the student body who may be interested. It is the meeting place of the experienced and the inexperienced, where the problems of one may be brought up before a number who may have had experience along the very line represented by the problem.

Professor Wilcox also pointed out the vast possibilities of radio in the future. It is only a matter of time before power will be transmitted by radio. Vacuum tubes now play an important part in multiplex telephony and may even be used for the rectification of power, replacing rotary converters. The difference between operation of radio apparatus and the thinking or engineering end, as the principles of radio, design of radio apparatus, and radio research, were clearly pointed out.

The radio station, which consists of a complete vacuum tube type of transmitter and receiver, will be put into operation again

at the earliest possible date. This station will be used primarily for carrying on experiments along the line of the latest developments in radio, in conjunction with the course in "Radio Communication," being given by Professor Wilcox. However, when time permits, actual communication will be carried on with other radio stations within the range of the transmitting apparatus. Signals from this station have been heard in Oklahoma and in Texas, according to post cards received by Professor Wilcox.

Meetings of the A. R. A. will be held every other Wednesday at 5 P. M., in the Physics Lecture Room. All radio men, and all others in the Institute who may be interested in radio or any of its branches, are urged and invited to attend the meetings of the Association.

EDWARD A. GOODNOW, Secretary.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

Chairman............................R. P. Burns
Treasurer...........................E. B. Mueser
Secretary...........................R. E. Grube

The first meeting for 1921-1922 of the Armour Branch of the American Institute of Electrical Engineers was held on September 29, 1921, at which time fifty-eight men were present.

Chairman R. P. Burns started the meeting with a short talk on the activities of the A. I. E. E. planned for the coming year. Prof. Snow followed with an informal talk on the value of the A. I. E. E. to students of electrical engineering. Prof. Snow also outlined the practical value of membership in the national organization, with particular reference to the articles appearing in the Journal.

The A. I. E. E. is going into things with more pep than ever this year. The policy of calling on members for short talks and discussions, at the regular meeting, is again being followed and so far has proved very interesting.

The writer feels that too much emphasis cannot be laid on the importance of attending the society meetings for the benefits

derived by attending cannot be obtained elsewhere and are worth while.

The second meeting was held on October 27, 1921. "Wireless Aboard Ship," by Mr. A. Mehrhof, was of extreme interest, in which he described the method by which ships are guided into harbors during a heavy fog.

"Railway Signaling," by Mr. R. S. Kenrick, was very thoroughly discussed. He described the different methods used and showed the contrast between old and new methods of railway signaling.

The A. I. E. E. has made arrangements for a Smoker on December 2, 1921, at which time a motion picture film on the "Life of Thomas Edison," will be shown. We also have the promise of a prominent Chicago electrical engineer to give us a talk that will be of interest to all. Come, fellow A. I. E. E. members, and get together, and make this the best year that the Armour Branch has ever seen.

R. E. Grube, Secy.

THE CHEMICAL SOCIETY OF THE ARMOUR INSTITUTE OF TECHNOLOGY

The Armour Chemical Society held its first meeting of the year 1921-22 at the Institute on September 28, 1921. There were about thirty-five members present. Officers were elected for the coming year as follows:

President..........................J. W. McCaffrey
Vice-President........................G. D. Crane
Secretary..........................C. B. James, Jr.
Treasurer........................B. Z. Nowakowski

The new slate of officers, together with the worthy members of the Senior and Junior Class, expect great developments in the society during the coming year.

It is the desire of the President that the type of monthly meetings be somewhat changed, in that, rather than having

speakers from the industrial world, discussions be held among the members regarding their own particular experiences and observations. It is thought that with this kind of meetings, more immediate and practical benefit can be derived by those attending. We also contemplate calling on professors of the chemical department to discuss with us vital topics of particular concern. It is also hoped that the members of the society will bring before the club for discussion any individual difficulties encountered while at work in the laboratories.

At our last regular meeting, Oct. 26, our worthy chief, Prof. McCormack, discussed the meaning of the phrase "a chemical engineer." In his talk he outlined for us the real essentials of a chemical engineer. We are sure that many of those present received some new food for thought, if they were not altogether corrected in their ideas of what constitutes a real chemical engineer.

We want the Sophomores and Freshmen to feel perfectly welcome to attend the meetings of the society whenever they have the opportunity. Possibly some of their Senior and Junior schoolmates will be shining examples and even inspirations to them in their field.

A smoker is being planned for the near future, date to be posted, when he expect to see every man really interested in the society on deck.

With all of these ideas in mind, let's get going, chemicals, and make this the most active society in the Institute.

CHAS. B. JAMES, JR., Sec'y.

COLLEGE NOTES

Assemblies.

The student body has had the privilege of attending two assemblies of interest and value during the first two months of this school year.

At the first, held during Fire and Accident Prevention Week, Mr. John O'Leary, ex-President of the Chicago Association of Commerce, addressed the audience. Mr. O'Leary was a student at the Armour Academy in 1893. His account of the rise of Chicago from the ruins of 1871 and the outstanding accomplishments of the city since that time, followed by his idea as to the requisites for present and future progress, was well-timed. The particular point of the discussion was the need, particularly by engineers, of recognition and acceptance of the responsibility implied by our citizenship and through this, the building up of a greater Chicago with a political government of service and a commercial and business life recognizing a high standard of ethics.

His presentation of a symbolic interpretation of the name—Chicago—was interesting:

C—*Character*
H—*Home*
I—*Integrity*
C—*Courage*
A—*Achievement*
G—*God*
O—*Opportunity*

At the second assembly, held Oct. 25, the Rev. Frederick F. Shannon, successor to our late President, Dr. Frank W. Gunsaulus as pastor of the Central Church, addressed the student body on the subject, "Success in Life," choosing as his text these words: "The fortunate people are not so much those who succeed in life but those who succeed in living." That the latter

is by far the most important, although to be able to succeed in life is the eminent call to the human being under the present social order, was the principal point made by Dr. Shannon. Saint Paul was cited as an example of one who succeeded in living but failed to succeed in life and R. L. Stevenson as one who did both. The statement was made by Dr. Shannon, and in that we will all concur, that the combination of the two things was never better illustrated than in the life of the late Dr. Gunsaulus. The address was ended by the quotation of "The House by the Side of the Road," reproduced on another page.

DEAN MONIN ON LEAVE OF ABSENCE; WILL TAKE SEVERAL MONTHS' VACATION IN EUROPE

Dean Monin sailed on November 4th from Montreal on the Canadian Pacific steamship "Montreal" bound for Naples. He will spend several months in rest and travel, and return to his duties at the Institute in September, 1922.

Since the sad death of Mrs. Monin, which occurred on July 31, 1921, Dean Monin's health has been somewhat impaired and it is the hope of his friends, which includes all those who have ever been blessed with his acquaintance, that a few months recuperation will bring him back to us in his old-time strength and vigor. The young men who have the honor and privilege—for it is both—of membership in his classes will be denied the splendid influence of his teaching and broad humanistic knowledge of the world's affairs for a brief period, but will feel well rewarded for this sacrifice if they may meet him as his "old self" again, in the class-room and the Dean's office, in September of next year.

Dean Monin shares honors with Mr. Agle as the two surviving members of the original staff of instruction when the Institute opened its doors in 1893. Through all these years no member of the faculty has been closer to the hearts of the students or more intimate in friendship than our beloved Dean Monin. In the important capacities of Dean and Professor, he has never failed

to impress on those about him the charm of his personality, as well as his kindly interest in everything pertaining to the Institute, of which he is the staunchest and most faithful of servants. To him ,the Institute is a great ideal, demanding and deserving the sternest devotion and the most ungrudging effort.

To Dean Monin, "Gentleman and scholar," man of letters, preceptor of true culture and, greatest of all, our "Loyal Friend," we bid Godspeed and Bon Voyage for a safe and certain return from a deserved and well earned vacation.

—H. M. R.

(A cablegram announcing the safe arrival of Dean Monin in Naples and bearing greetings to all his friends has been received. —Ed.)

THE ARMOUR "TECH" MUSICAL CLUBS

Our Glee Club and Orchestra was selected from the Clubs of about twenty colleges to make a trip to the Canal Zone to furnish entertainment for the government officials and military men located there.

In keeping with the governmental economy program the force of men employed in the Canal Zone has been cut to only forty per cent of the number formerly employed, and this policy has proved to be the downfall of our proposed Christmas tour.

However, the fact that the trip has been indefinitely cancelled does not in any way affect the standing of the Armour Tech Musical Clubs in case the practice of sending collegiate musical organizations to the Canal Zone be resumed.

In the past years the Clubs have not been organized in a way which would permit their functioning to the best of their ability. The Clubs have now been organized under the name of "The Armour Tech Musical Clubs," an association resting on a constitutional foundation as strong as could be constructed by the combined efforts of the Dean's office, a faculty representative, and

a few embryo engineers. The joint clubs will be piloted this season by the following men:

Director—Professor C. W. Leigh.
President—E. Walter Geisler.
Secretary—Jeff Corydon, Jr.
Treasurer—J. Warren McCaffrey.
Manager—Cecil Kirkhuff.
Leader of Glee Club—Edward A. Goodnow.
Leader of Orchestra—Tom Michels.

And of course, "Duke" (Rudolph Werner) will be the noble and faithful librarian, in custody of the music. J. C., Jr.

INSPECTION TRIPS

Chicago is an ideal location for a progressive technical institution. It offers the combined advantages of being the recognized commercial and engineering center of the West. The students of the Armour Institute of Technology are fortunate in having the opportunity to visit and inspect modern plants or notable examples of engineering skill without the inconvenience, expense, and loss of time necessary for an extended trip.

The Institute is surrounded by the best in all branches of engineering and construction. The frequent inspection trips made by the various departments as a part of their regular program bring the students in close contact with the highest class of work in their respective lines.

On Saturday, October 15, the Senior Class in Electrical Engineering, twenty-five in number, under the direction of Prof. Snow, made an inspection visit to the Sanitary District Hydraulic Power Plant near Lockport, and also to the Public Service Corporation Plant No. 9, located about three miles below Joliet. The trip was made by automobiles.

Some of the interesting features reported in connection with Plant No. 9 are as follows:

The boiler pressure is approximately 360 pounds to the square inch. The capacity of the plant is 20,000 kva. The power is

generated by 2 steam turbo-electric units each of 10,000 kva. capacity, built by the General Electric Company. The boilers are of the vertical cross-drum type, manufactured by Babcock Wilcox Company. Nearly all the auxiliaries are motor driven. The boiler feed pumps alone are steam driven. The prime movers in this case are 4-stage turbines. The fact that there are so few steam driven auxiliaries leads to some special refinements in feed water heating. The condensate is delivered back to the heaters by the condensate pumps after it has passed through a pre-heater at the top of the condensers themselves. If the desired temperature is not reached on account of a lack of exhaust steam, live steam is introduced, this being taken from the fourth stage of the turbine through a bleeder, under thermostatic control. As is usual, the water is then delivered by the boiler feed pumps through the economizer into the boilers. These pumps work under a head of about 375 lbs. to the square inch. The lightning arresters are of the electrolytic outdoor type and are placed on the roof of the station. The whole construction and design of the plant is such that the number of men employed in its operation is reduced to minimum. It is also remarkable in that natural lighting and ventilation has apparently been kept well in the foreground throughout the design.

The second station visited was the Sanitary District Power Plant. This is located at the southern terminus of the drainage canal between Joliet and Lockport. The topography of the country is such that a fall of about 40 feet is obtained at this point. This power is utilized by seven horizontal turbines, each driving a 4000 kva. slow speed alternator of the horizontal type, and 3 exciter units. The power generated here is stepped up to 44,000 volts and transmitted to the sub-station at 31st Street and Western Avenue, Chicago. The striking feature of this plant, which is common to most hydraulic plants, is its simplicity.

Both plants are controlled electrically from a central low-tension control board.

The Juniors and Seniors in Civil Engineering have had four inspection visits since September, these being to the Inland Steel Co. at Indiana Harbor, Ind., the Portland Cement Works at Buffington, Ind., the Morava Construction Co., and the Produce Terminal Corporation in the city.

The new electrical installations at the Inland Steel Co. were particularly interesting. The visit to the Produce Terminal Corporation was to inspect their filtration, ice making, and pumping plant. This company furnishes water for boiler purposes for the Stock Yards and the Chicago Junction Railway, the water being the filtered and chlorinated product of sewage passing through the yards. The plant consists of six settling basins, eight rapid filters; and a deep well, with the necessary pumps, chlorination apparatus, and alum injection apparatus.

Interesting features seen were a 1700 foot well with an air lift pump and a 270 foot reinforced concrete stack built two years ago, and having no cracks yet developed. This stack is about 10 feet in diameter, 18 inches thick at the bottom and 6 inches at the top. The pouring of the concrete was a continuous operation, movable forms being used.

Daniel Roesch, Associate Professor of Gas Engineering, Armour Institute of Technology, addressed the Mid-West Section, Society of Automotive Engineers, at a meeting held in the rooms of the Western Society of Engineers, Chicago, on October 31, 1921. His subject related to fuel utilization of the motor car and showed in detail all heat and power losses which occur in the engine and chassis.

About one hundred members of the society were present. The importance of the points brought out in Mr. Roesch's presentation of the subject caused much valuable discussion at the close of his address. Wooden forms with surfaces designed to visualize three variables and representing the gasoline consumption at all speeds and loads for automobile engines were shown. These were developed in the laboratories of the Armour Institute of Technology. Their presentation created a great deal of interest.

George S. Allison, Comptroller of the Armour Institute of Technology, attended the Conference of Buyers for Educational Institutions, held at Indianapolis, Ind., on October 11, 1921, in connection with the Annual Convention of the National Association of Purchasing Agents. Delegates from nineteen universities and colleges were present. He was made chairman of one of the divisional committees appointed at the conference.

Mr. Allison also discussed the subject of Central Purchasing Organization and Procedure at the Conference on Business Organization and Administration in Colleges and Universities held at Peoria, Illinois, on October 21, 1921. He was elected vice president of the newly formed state organization of University and College Business Officers, which held its first meeting at that time. Twenty-three colleges and universities of Illinois were represented. The organization is to be permanent and will meet annually.

Tau Beta Pi announces the pledging of the following men at the beginning of their Senior year: Tom Michels, W. S. Trowbridge, D. S. Jennings, E. C. Rieger, G. V. Bradbury, L. M. Holmes, H. R. Wing, D. R. Hyde, J. W. McCaffrey, W. M. Baker, E. B. Mueser.

The following men have been pledged to Phi Lambda Upsilon, honorary chemical fraternity: E. F. Dhus, A. Davis, B. Rosenzwieg, and Ben Sites.

J. B. Thompson and H. I. Hultgren, Seniors, and H. G. Love, W. H. O'Brien. V. E. Lowden, and H. M. Piety, Juniors, have been pledged to Eta Kappa Nu.

New Faculty Members.

The steady growth of the institution and the development of new phases of work in the various departments has added seven new members to the faculty of the Armour Institute of Technology for the year 1921-1922. They are as follows:

HENRY J. KESNER, C. E., Associate Professor of Civil Engineering, obtained his B. A. at the University of Colorado in 1905, his B. S. in C. E. in 1907, and his C. E. in 1911. Professor Kesner has been connected with the U. S. Reclamation Service, Interstate Commerce Commission, C. B. & Q. R. R., Foundation Company of New York, and the State Highway Commissions of Indiana and Wyoming. His teaching experience includes an instructorship at the University of Minnesota, an Assistant Professorship in Civil Engineering at the University of California

and an Associate Professorship in Civil Engineering at Purdue University. Professor Kesner is an Associate Member of the American Society of Civil Engineers, Member of the Society for the Promotion of Engineering Education, and of Phi Beta Kappa, Sigma Xi, Tau Beta Pi, and Beta Theta Pi.

RAYMOND S. NELSON, B. S., Instructor in Actuarial Science, is a graduate of Northwestern University. His past connections include the Michigan Inspection Bureau, the American Eagle Fire Insurance Co., of New York, and the Ohio Inspection Bureau. At present Mr. Nelson serves jointly with the Western Actuarial Bureau, and the Armour Institute of Technology in the Department of Fire Protection Engineering.

W. C. KRAFFT, B. A., Athletic Director and Coach, is a graduate of the Northwestern College of Naperville, Ill., with post-graduate courses in the coaching schools of the Universities of Iowa and Illinois. Mr. Krafft has been Coach and Athletic Director at Waukegan Township High School and is a member of the Approved Officials Association of Chicago and of the Officials Association of the Mid-West football league.

F. C. LUSK, Ph. B., Lecturer on Business Law, received his degree from the University of Chicago in 1917.

WALLACE BRUCE AMSBARY, Lecturer in General Literature at Armour Institute of Technology, has been under direction of the most important lyceum and chautauqua managers for the last twenty years, with the Extension Division of the Universiy of Wisconsin for three years, and with the Extension Division of the University of North Dakota for two years. He has often appeared at Chautauqua Institution of New York; has lectured at Yale University, at the University of Washington, and numerous other educational institutions throughout the country. Mr. Amsbary is the author of "The Ballads of Bourbonnais," "The Romance and Poetry of the Northland," and is a contributor to numerous magazines. He is an honorary member of the Chicago Kiwanis Club, a member of the Press Club of Chicago, the Society of Midland Authors, and the Writers' Guild of Chicago. Hs has been Vice-President of the International Lyceum and Chautauqua Association for two years.

R. J. FOSTER, B. S., Instructor in Actuarial Science, received his B. S. in Mechanical Engineering from the University of Nebraska. Mr. Foster has for eight years been engaged in the design and manufacture of gas tractors and aviation engines.

MISS NELL STEELE, Librarian, is a graduate of Lake Forest College. Miss Steele has been Assistant Librarian of the Ryerson Library at the Art Institute from 1915-1918, of the National Safety Council Engineering Reference Library 1919-1921, and was the Camp Librarian for the War Department from 1919-1921. She is a member of the Special Library Association and the American Library Association.

THE HIGH COST OF UGLINESS

In the July Review of Reviews, Andrew W. Crawford, Secretary of the Art Jury of Philadelphia, points out that America is not only realizing that ugly things cost money, but that the beautiful, whether it be a commercial bridge or a lamp standard, is cheaper in original cost than the hideous. He states that much of the ugliness of American cities is due to engineers whose teaching in technical schools has been erroneous. They have been taught construction, but not design.

"Merely to connect the bottom of three lead pipes so that water spouts out of the upper ends, is not to design a fountain," says Mr. Crawford. Our hideous gridiron street system shows the teaching of construction but ignorance of design. And so the story might continue through bridges, sidewalks, and what not in every community in the country.

THE ALUMNUS

Being That Part of **The Armour Engineer** Devoted to Personal Mention of the Graduates of the Armour Institute of Technology and to the Affairs of the Armour Alumni Association.
Communications should be addressed to
W. J. Bentley, Armour Institute of Technology, Chicago, Ill.

Officers of the Armour Alumni Association for 1921-22.

W. A. Kellner '10..................President
Ray J. Koch '13...............Vice-President
Harold S. White '17................Treasurer
Walter H. Hallstein '14....Recording Secretary
Walter J. Bentley '20..Corresponding Secretary
Morris W. Lee '99......Master of Ceremonies

Board of Managers.

Retiring 1922	Retiring 1923	Retiring 1924
R. M. Henderson '02	C. A. Knuepfer '15	W. D. Matthews '99
J. C. Penn '05	F. C. Dierking '12	Wm. H. Long '02
B. S. Carr '15	Sidney V. James '07	M. A. Smith '10

ASSOCIATION ACTIVITIES

When we consider the position the Armour Institute of Technology holds in the educational world and the large number of its successful graduates, we see how our Alumni Association could be a live organization and a help to the school and to its members. We know our Alma Mater is the best school in the world and we want the world to know it. Her sons have taken the measure of the world's problems and proved they are men. For an Armour man to decide to see a proposition through, is to guarantee its success. Our Alumni Association must be a success.

At the first meeting of the present Officers and Board of Managers, there was such enthusiasm among them that we decided to institute innovations. If our reunions were closer together.

they would produce closer bonds of friendship and interest. Therefore, we have adopted the plan of having semi-monthly luncheons. These are held on the first and third Fridays of each month at the Hamilton Club, Chicago. The luncheons are served promptly at 12:15 P. M., and are entirely informal. *No business will be transacted at them.* You can obtain a substantial meal at a reasonable price and leave when *you* have finished. We are not presenting to you an untried plan, for the attendance is going up by leaps and bounds. Everyone has found that there is rare good fellowship and that they make many social and business acquaintances. The first luncheon was held on October 7 with an attendance of thirty-one. The second was held on October 21 and sixty-five were present. If you have not been present, come to the next one and find out what you have been missing.

"The Armour Engineer" is essentially an Alumni publication. Let us make it of real interest to every Alumnus. Send in all changes of address, promotion in your business organization, marriages, births, etc.—in fact any and every personal item. Haven't you said many times, "I would like to know what has happened to So-andSo. I wonder what he is doing?" If you will aid us in this way, we can make the Alumnus Section of the Armour Engineer of real interest to each class.

The nucleus we have has worked wonders, and with your help there is no limit to the possibilities. If you have any suggestions to make, let us have them. We are seeking criticism and are open to any plan for improvement. Tell all the Armour men you know what we are doing and get them to co-operate. We will inform you of new developments as soon as possible.

W. J. Bentley,
Corresponding Secretary.

PERSONALS

G. F. Hayden '00, who is Consulting Engineer for the Continental Insurance Company, visited the Institute recently.

John B. Swift '01 can now be reached at 645 No. Michigan Avenue, Chicago.

Arnold A. Hepp '06 is now Assistant Manager of Johnson & Higgins Company, Chicago, Ill.

George Niestadt '03 and '07, Structural Engineer, has an office at 53 W. Jackson Blvd.

W. H. Hallstein '14 is now living at 2749 Hampton Court, Chicago.

Emil J. Hepp '14 is with the Springfield Fire and Marine Insurance Company, Chicago.

Maurice L. Wilcox '16, while still with the White Motor Company, has been transferred to Dallas, Texas.

C. I. Carlson '19 is now teaching Mechanical Drawing in the High School of Aurora, Ill. He may be addressed at 245 Hammond Avenue.

Emil G. Vogt '20 is now living at 4118 Broadway, Chicago. Emil is Chemist for the Chicago White Lead & Oil Company.

Edward Mundt '21 is back in his home town, Lloyd, Montana.

William Robert Wilson '06, formerly Vice-President of the Irving National Bank, New York City, has been elected recently to the presidency of the Maxwell Motor Corporation and the Chalmers Motor Corporation. Mr. Wilson received his M.E. from the Institute in 1911.

BOOK NOTES

"A laboratory worker or an engineer would be almost as helpless without books as without balances or transit." (A. L. A. Pamphlet.)

Interesting recent additions to the library are:

MECHANICAL ENGINEERING

Betts, Harold S. *Timber.*

Engineers, manufacturers and users of lumber, students of engineering and forestry will find here a thorough discussion of the mechanical properties of wood.

Callender, H. L. *Properties of steam and thermodynamic theory of turbines.*

A writer in Engineering says of this book. "Professor Callender has made accessible to engineers in general the results of the revolutionary improvements in the thermodynamic tratment of vapors in general and steam in particular."

Dibble, Samuel E. *Elements of plumbing.*

This book gives the reader a broad view of the importance of good plumbing. It discusses the correct use of tools and metals and the correct installation of jobs.

Furman, Franklin D. *Cams, elementary and advanced.*

The author presents this important subject fully and clearly, the processes of design being most graphical and readily followed by practical shopmen and draftsmen, as well as by technical students.

Herington, C. F. *Powdered coal as fuel.*

"Many believe that powdered coal will solve the fuel question in the United States and it is a certainty that many firms are finding their coal bills cut down to a startling degree."

Hobbs, Elliott & Consoliver. *Gasoline Automobile.*

A thorough and practical explanation of the fundamental principles of automobile construction, operation and repair.

KERSHAW, J. B. C. *Low-grade and waste fuels for power generation.*

To explain how fuel economy may be achieved by the use of material now wasted in most plants is the purpose of this most timely book.

TAYLOR, H. S. *Fuel production and utilization.*

The author demonstrates the interest and importance of the effective utilization of our fuel reserves .

ELECTRICAL ENGINEERING

BRAYMER, DANIEL H. *Armature winding and motor repair.*

Practical information and data covering winding and reconnecting procedure for direct and alternating current machines.

CROFT, TERRELL. *Central stations.*

Discusses fully the design and operation of central-station systems, clearly and completely.

POOLE, JOSEPH. *Practical telephone handbook and guide to the telephone exchange.*

The book covers various phases of the subject as overhead and underground engineering, switchboard equipment and testing, investigating and operating departments.

Year Book of Wireless Telegraphy and Telephony.

A complete reference book of radio information, including the laws and regulations, location of wireless stations, technical progress in the various countries and articles on the subject.

CIVIL ENGINEERING

CARD, S. F. *Air navigation notes and examples.*

The methods adopted and the order in which the various items are dealt with are those which have proved to be the most effective.

EYTINGE, BRUCE. *Flying guide and log book.*

A handbook of valuable information for the aviator and those interested in commercial aviation.

The Armour Engineer

VOLUME XIII. JANUARY, 1922 NO. 2.

AUTOMATIC BLOCK SIGNALING

J. E. Saunders, '07, E. E. '11,
Assistant Chief Engineer, Union Switch & Signal Co., Swissvale, Pennsylvania.

Railway signaling is a means of transmitting information from the person directing or affecting the movement of the train to those controlling such movement. That trains be spaced safely is fundamental. This requires that trains running in the same direction be separated by a space of at least braking distance, plus the distance required for the enginemen to observe signal indications, and to act. Double this spacing should be provided for opposing train movements. Automatic signals perform the required work from day to day and from year to year so accurately and reliably as to make them the greatest factor for safety in handling railway traffic.

Automatic signals are a necessity in modern railroading. They are not dependent alone upon the lives they save for their popularity and justification; the prevention of property loss and damage more than pay for their initial installation, and the reduction in train delay secured by their use overshadows maintenance and operation charges. Secondary to the increment in safety, but of no less importance from an investment viewpoint, is the considerable increase in track capacity made possible by automatic signaling. *The double tracking of single track lines may be delayed for years by applying automatic signals to the existing single track;* the signals will pay for themselves many times over before the increase in traffic again forces the consideration of a second track.

ECONOMY OF AUTOMATIC SIGNALS

A careful check of train operation covering several years before and after automatic signals were installed on a single track railroad, showed a saving of one hour in running time over a

division for each freight train, due to the signals. With an aver age of sixteen trains a day, this resulted in a saving of sixteen train hours on the one division. This is equivalent to over three locomotives, and 278 freight cars being released for other service The saving in equipment investment is in excess of one million dollars, and in over-time more than $14,000, or a net earning on the cost of the automatic block signal installation of 23 per cent

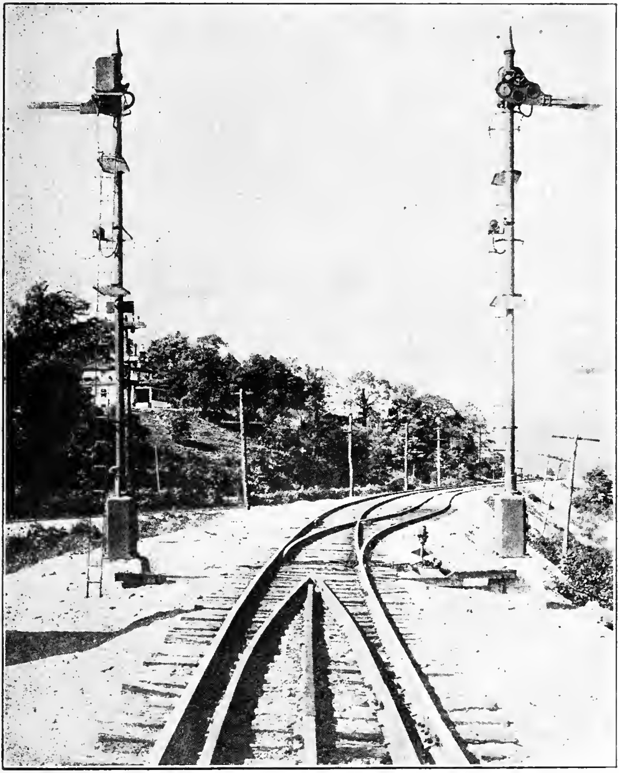
Much has been said and written recently concerning the increase in traffic to be handled with consequent reduction in freight congestion, by increasing the car mileage. There are two ways in which to secure this result. One is the avoidance of excessive terminal delay, and the other the increase in speed of trains. The first is to be secured by improvements in terminal facilities, such as yards, engine houses, and by the judicious installation of interlockings; the second by the use of automatic block signals. On the division mentioned in the preceding paragraph, automatic signals allowed an increase in freight train speed from an average of 10.6 miles per hour to 12.5 miles per hour.

A record of the effect produced by substituting automatic signals for manual block on the Susquehanna Division of the Erie Railroad is equally as strong an argument for the former, although in this instance a double track railroad is concerned. The change from 90 manual blocks to 296 automatic blocks was made with a decrease of signalmen from 136 to 58, and a saving in train time of 15 per cent, and in the cost of train operation of practically $88,000 a year. This saving, expressed in number of trains for a period of one year, is 7.6 per cent.

One division superintendent reports concerning automatic block signals: "The automatic signals have been a success in facilitating the movement of trains, and have increased safety in operation. With the use of the automatic signals we have been able to dispense with the use of "31" train orders to a considerable extent, and have avoided the necessity of stopping heavy tonnage trains by the use of "19" orders delivered by operators. We have had no accidents since the installation of these signals, due to broken rails, open switches, etc. On the division, 107 miles (82 single, 25 double track), handling the usual business would require twenty-two additional operators to handle by Manual Block, an expense of approximately $18,500 per annum. We have an average of about 115 meets per day. Under Manual Block system these delays would amount to about ten hours per

day, or about $10,000 per annum. Under the eight hour per day basis, nearly every minute delay means over-time."

It is estimated that there are 26,000 freight locomotives in service of 188,000 miles of road *not now equipped with automatic block signals.*



Style T-2 Automatic Signals, Monongahela Railway.

Delays to freight trains that can be eliminated under the automatic block system can be averaged on a conservative basis at one hour per day per locomotive. For 26,000 locomotives this is equivalent to $7,800,000 per annum: $7,800,000 is interest on an investment of $156,000,000.

New rolling stock will only speed up *some* of the trains *all* of the time. Automatic signals speed up *all* of the trains *all* of the time. To secure maximum capacity from a single track railroad, consideration must be given to the kinds of traffic handled and how this can be spread over the twenty-four hours of each day. The location of passing sidings is also very important. When these three factors have been taken into consideration, and automatic signals are installed, a given section of track is prepared for handling the greatest possible volume of traffic. Double-tracking is not ordinarily justified until traffic exceeds the maximum capacity thus established.

MANUAL VS. AUTOMATIC BLOCK

Two methods for the protection of railway traffic are in use. One is the time interval and the other the space interval, to be maintained between trains. In the time interval, the protection of trains depends upon their remaining the distance apart represented by the five or ten minutes required by rule at telegraph offices and interlocking plants. This is a very uncertain and unreliable method of handling traffic, as the records of many accidents will testify.

The space interval is secured by either of two forms of block signaling: manual or automatic. In the ordinary manual block, the train does not control the position of the signals; in the controlled manual block, the position of the signals is determined to some extent by track occupancy; in the automatic block, the train completely controls the signals governing movement over the track it occupies. The manual block lengths are ordinarily the same for both ascending and descending grades. The automatic block takes cognizance of the time required per block and braking distances, by signal locations on descending grades farther apart than ascending. Dangerous conditions and practices often exist where non-automatic block signals are in use. To avoid delays due to long blocks, chances are taken; hence the many variations of "permissive" blocking.

Conclusive evidence of the greater economy when automatic is substituted for manual block has been secured by several railroads. The delays due to manual block signals may be charged to:

1. Long block sections.
2. Blocks of irregular length.

3. Time lost by trains operating under *written* train orders, due to the fact that trains are required either to slow down or to stop to receive orders. This applies particularly to double track operation, but has application to single track as well, although to a lesser extent.

The manual block preceded the automatic, and represented a very important step forward in the safe handling of trains. While the former is still quite generally used in its various forms, it is not now being installed to as great an extent as the latter. Where ultimate cost must be neglected to secure low first cost, and as a temporary expedient, manual block signaling will be used, but where consideration is given the increase in factor of safety due to less dependence upon the human element, and where the cost of operation, as well as first cost, is taken into account, automatic block signaling will be chosen.

TRAIN OPERATION BY SIGNAL INDICATION

Railway signaling has been defined as a means of transmitting information. Signals are of primary importance as a medium for doing this, because by their use a train may continue its movement while those in charge are receiving instructions. "Why stop a moving train to permit it to proceed" is aptly answered by automatic and interlocking signals.

Nothing is more simple or less probable of misinterpretation than the indications of fixed signals. By this means, instructions are given when action is to be taken, not at some time remotely related thereto. *Train orders* are written instructions which must be delivered to the conductor and engineman of a train, and which refer to action to be taken at *some time in the future*. They are subject to mistakes in preparation, transmission, delivery, and comprehension. *Automatic signals,* on the other hand, give visual indication for action to be taken *immediately*. Their reliability in detecting and interpreting track conditions affecting the movement of trains is proverbial. The only possibility of a mistake—that of comprehension of the meaning of their aspects by the engineman—is minimized by the simplicity of their indications. The language of the fixed signal is easy to understand and hard to forget. Safety of train operation under signal indications is largely independent of the human element, which, it must be conceded, is far from infallible.

ELEMENTS OF AUTOMATIC BLOCK SIGNALING

Purpose: Automatic block signaling is a means for securing the safe spacing of railway trains by the use of power operated and automatically controlled signals. They provide that trains running in the same direction shall be given rear end protection, and opposing trains given both head and rear end protection. Automatic block signals are signals fixed in location, which indicate whether a train shall stop, proceed, or proceed under control. Factors determining signal indications are track occupancy, either main track or cars on turnouts fouling main track, position of switches, broken rails, or other derangement of the track affecting the safe passage of trains. The road to be signaled is divided into blocks, which by definition, are lengths of track of defined limits, the use of which by trains is governed by automatic block signals.

Types of Signals: Signals are generally of the semaphore type, operating in the upper right hand quadrant, and are located to the right of the track as viewed from an approaching train, the movement of which they govern. In some countries, and to meet special requirements at certain locations in America, signals may be located to the left of the track protected; under certain other conditions, semaphore signals may be made to indicate in the upper left or lower right hand quadrant, but common practice in America requires right hand signal locations with indications in the upper right hand quadrant, as illustrated.

Signals may be of the position light type, which provide indications by rows of lights easily distinguishable during both day and night time, or of the color light type equipped with lamps and lenses of sufficient intensity and range to provide the color indications of semaphore signals by day as well as by night.

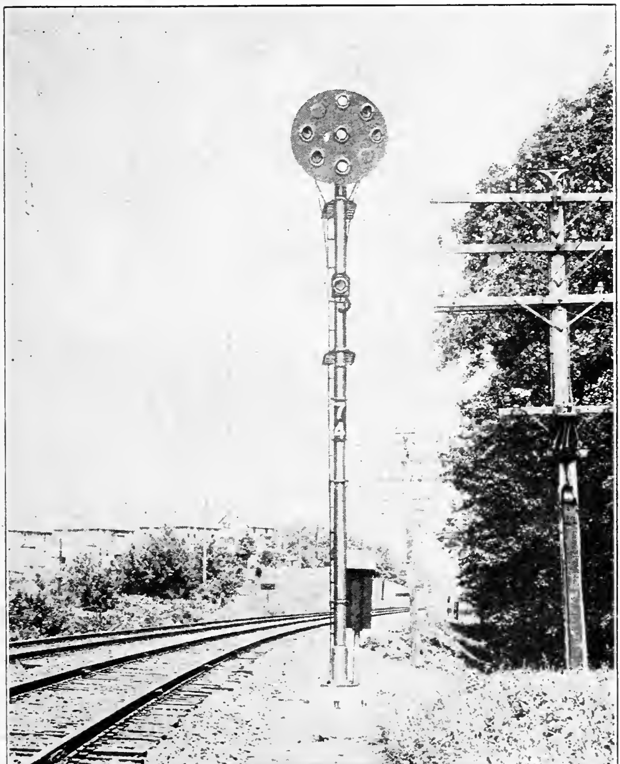
Where located on signal bridges, the signals may be over the middle of the track, the right hand running rail, or the center of the mid-track space to the right of the track protected. Where track centers interfere with the proper location of ground signals, and a signal bridge is not desired, a signal may be supported on a "half-bridge" or cantilever mast, or on a bracket post.

Dwarf signals are similar to high signals but do not stand more than three or four feet above the base of rail. They are used for slow speed train movements only.

Signal Indications: Only basic indications and the more common aspects will be defined. Past practice and traffic requre-

ments have resulted in deviations from the indications described, on a number of railways

Indication	*Position of Arm*	*Color of Light*
STOP	Horizontal	Red
PROCEED WITH CAUTION	Inclined upward 45°	Yellow
PROCEED	Vertical	Green



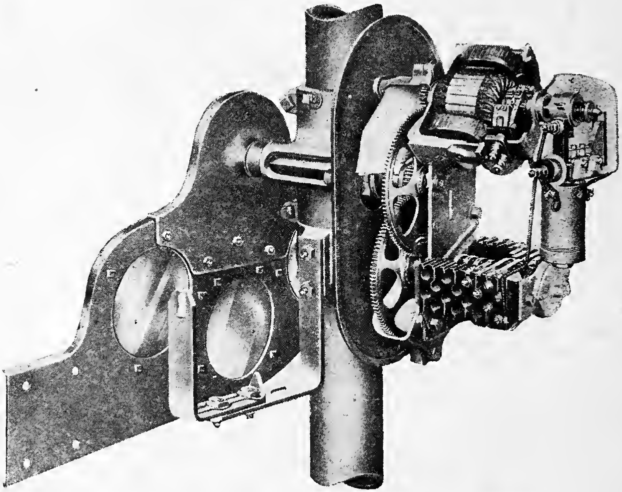
Position Light Signals, Pennsylvania Railroad.

Supplementary indications may provide:

"Proceed at low speed"

"Proceed at medium speed"

While block signals govern the movement of trains over a specified section of track, they convey no authority to disregard other limitations of train movement or speed which may be the result of local conditions, nor ordinarily to disregard superiority of other trains, by right, class or direction.



Style T-2 Signal Mechanism with Parts Exposed

The proceed indication of a signal then allows a train to proceed at such a speed as may be safe, as determined by other conditions concerning which the train crews are informed.

The caution indication provides for train movement under control with such limitations as are prescribed by rule.

The stop indication of an automatic signal differs in its meaning from that of other signals—interlocking or manually controlled block. The stop indication for an automatic signal means "Stop and then proceed," with certain limitations. There is a further differentiation between double track and single track. On double track a train may stop and then proceed under control, expecting to find a train in the block, broken rail, obstruc-

tion, or switch not properly set. On single track the action taken after a train stops is determined by the system of signaling in use.

Various means are employed for designating automatic signals. A "stop and proceed" signal is ordinarily indicated by the use of a pointed blade and by a marker light below and to the left of the active light. On some roads the number plate, which is always a part of a "stop and proceed" signal, is used alone as a designation of the kind of signal. "Absolute" signals used in the "APB" system of single-track signaling ordinarily have square end blades and a marker light in a vertical line with the active light.

Practice as to the painting of blades varies considerably, but this is not of serious moment where three-position signals are used, as the position of the blade, rather than its color, determines the indication. The general practice is to paint the front sides of signal blades a color which can be readily discerned, and the back sides some neutral color which will blend with the background. The more ordinary practice is indicated by the Signal Association Standard provision that the front of a blade may be painted either (1) red with white stripe, or (2) yellow with black stripe. The back and edges are to be painted black in either case.

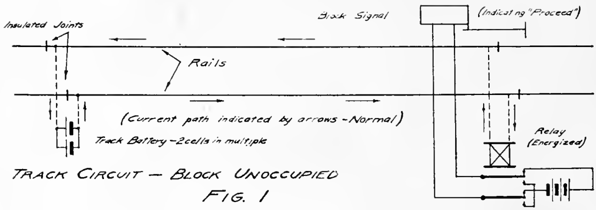
Practice is more nearly uniform for light colors, although on a few roads white indicates "proceed"; green "proceed with caution"; and red "stop."

SIGNAL CONTROL

Track Circuits: The presence of a car or train on a given section of track may be detected by means of a track circuit. This consists of a section of track, separated electrically from adjacent sections by insulated joints, with a battery or transformer for supplying current at one end and a relay which receives current through the two rails at the other.

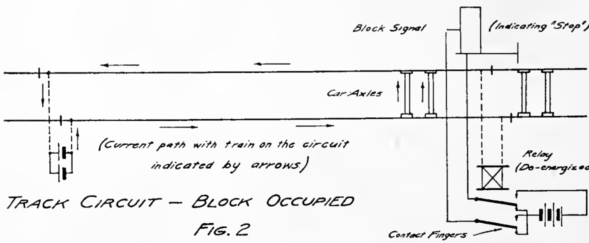
A simple track circuit is shown in Fig. 1. Current flows from the battery, as indicated by arrows, through one rail to the relay and thence returns to the battery through the other rail. Under this condition, no train on the track section, the relay—an electro-magetic device—will be energized, and certain contacts, termed "front contacts," will be closed. The closing of these front contacts completes a local circuit which allows the signal to clear. The change in conditions when a train enters the track section

is shown in Fig. 2. Instead of passing through the relay windings, the current from the battery will take the lower resistance path through the car wheels and axles, as indicated by arrows. The relay, being thus shunted out becomes de-energized, its front contacts open, and other contacts, called "back contacts," close. The opening of the front contacts breaks the local circuit controlling the signal, which will immediately assume the stop position. When the train passes off the track section the relay contacts will again close, allowing the signal to clear.



TRACK CIRCUIT — BLOCK UNOCCUPIED

FIG. 1



TRACK CIRCUIT — BLOCK OCCUPIED

FIG. 2

The track circuit just described is that which utilizes direct current energy, and may be of any length from 30 ft. to about 5,000 ft., the upper limit being determined by leakage conditions from rail to rail. The battery may be either primary or storage. Where alternating current is used, a small track transformer replaces the battery, and a relay of a different type, but functioning in the same manner, completes the circuit.

Alternating current track circuits may be 10,000 ft. or of even greater length, the limit depending upon ballast and tie conditions as in direct current circuits.

A break in the circuit between the battery or transformer and relay will prevent current reaching the relay windings, and it will become de-energized. A broken rail ordinarily brings about this result, although in case of incomplete fracture, and when

there is a good leakage path for current around the break, the relay may remain energized. It is remarkable how many broken rails are detected by automatic signals.

Fouling protection at siding switches is secured by extending the track circuit to the clearance post. Thus, if a car be left in a position where it may be side-swiped, the signals will be caused to indicate "Stop."

LINE CIRCUITS

It is often necessary for a signal to be controlled through a line circuit because this control may be affected by more than one track circuit, and also because the track relay is not always located near enough the signal to avoid this. Line circuits are always required for single track signaling. It is, however, possible to avoid the additional expense of such circuits for double track signaling by using what is known as a polarized circuit

OPERATING CIRCUITS

Signals take energy not only while clearing but also, in a decreased amount, all the time they indicate "Proceed" or "Proceed with caution." They are returned to "Stop" by gravity, so that any interruption of current supply will cause a signal to assume a safe aspect.

The circuit for the signal motor extends from a local battery, through the front or energized contacts of control relays and a circuit controller, to the motor. While in the caution or clear position, the motor is cut out and a high resistance holding device is connected with battery through the circuit just described. A simplified form of the signal operating circuit is shown in Figs. 1 and 2. Signals are ordinarily supplied with direct current from a 10 volt battery, or alternating current at 110 volts obtained from a transformer.

CONTROL BY SWITCHES

The changing of a switch from its normal position will cause all signals governing train movements over the section in which it is located, to assume restrictive positions—ordinarily that indicating "Stop." This control is exercised by means of circuit controllers connected to the switch points. On double track, either switch of a cross-over between main tracks will affect the signals on both tracks. Derails and switches on the siding end of turnouts and cross-overs to unsignaled track also control the signals.

CONTROL OF OUTLYING SWITCHES

While entry to a signaled track can be automatically controlled by means of switch indicators, yet greater efficiency in handling traffic can sometimes be obtained by a manual control of outlying switches. A leverman or operator at an adjacent tower or station can exercise control over an isolated switch by having an electric switch lock installed. Or, if traffic is to be handled with minimum delay, trains may take or leave sidings without stopping where a low voltage electric switch movement is installed and placed under the control of the leverman or operator. Such an installation is especially recommended where trains might otherwise have to stop on grades.

TAKE SIDING INDICATORS

Time can be saved in train operation by providing a means for informing enginemen of trains—generally freight—approaching stations where it is necessary to take siding. "Take Siding" indicators, for control by towerman or operator at an adjacent station, can be readily installed in conjunction with automatic signals. This indicator may be located near the heading-in switch, with an advance warning provided by one of the automatic signals, or it may be located several thousand feet from the switch.

SEMI-AUTOMATIC CONTROL OF SIGNALS

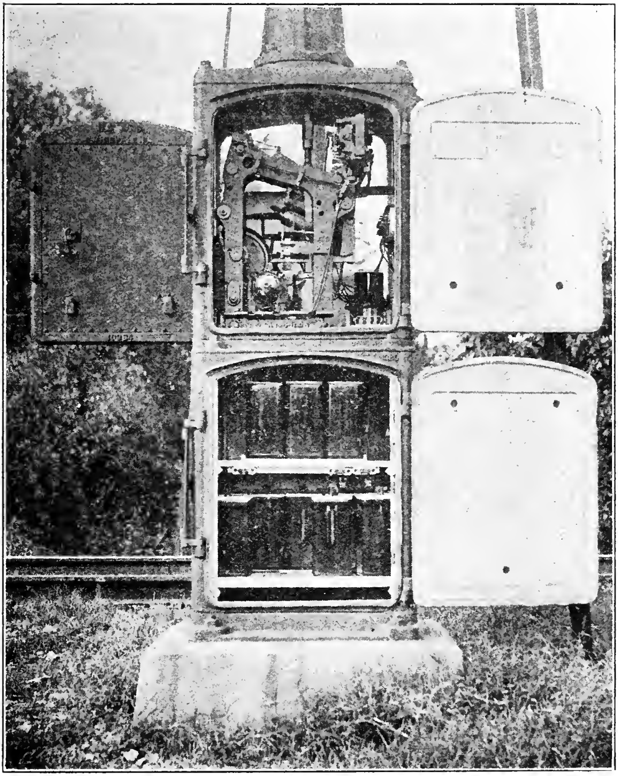
Automatic signaling can be extended through interlocking plants by using power operated signals and putting these under the joint control of track circuits and interlocking levers. The track circuits can also be made to electrically lock the interlocked switches which come within their limits.

APPARATUS

Signals: There are two general classes of signals for the control of railway trains in use today; the semaphore and the light signal. The semaphore signal is supplied for location on the ground and on bridges, and arranged for both high and dwarf applications. The light signal is supplied in two distinct types—position light and color light. Either of these may be secured for ground or bridge location, and as a high or a dwarf signal.

Semaphore signals may be made to indicate in any quadrant either two or three positions, although the vast majority of these signals are now supplied for three position indications in the upper right hand quadrant, as previously described. Semaphore type signals may be again sub-divided into two kinds, those which

have their operating mechanisms at the base of the mast, and those with their mechanisms adjacent to the semaphore shaft at the top of the mast.



Style S Signal with Mechanism and Battery Exposed

Semaphore signals of both the bottom mast and top mast types are shown in accompanying illustrations. Those of the bottom mast are preferred because of the location of the operating mechanism where it can be easily reached by the maintainer. There are over 60,000 of these signals in service in the United States. The chief advantage of the top mast type of mechanism is that it

is located near its load, in this way avoiding the necessity of a mechanical connection between the top and bottom of the mast.

Position light signals are a development of the last few years, having been first applied extensively on the Pennsylvania Railroad. By means of rows of electric lamps the positions formerly assumed by signal blades are reproduced by lines of light; thus a stop indication is given by a horizontal line, a caution indication by a line extending diagonally upward, and a clear indication by a vertical line. Various combinations of indications can be secured.

The lamps are 12 volts 6¾ watts and have a concentrated filament for the high signal, and 9 volts, 18 watts for the dwarf signal. The high signal lamps are specially based in order that the filament may always be at the focal point of the lens.

The color light signal has been developed to take care of two classes of traffic, one being that of high speed trunk lines, and the other lower speed interurban railways with short braking distances.

The style "L" signal light can be seen under average conditions of sunlight at a distance of 3,500 feet. The lamps used in this signal are: one 6 volt 28 watt, specially based, and one 60 volt 25 watt pilot lamp.

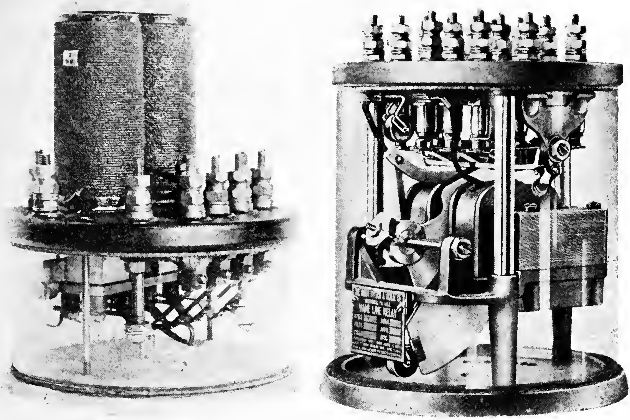
The style "N" color light signal is intended for interurban railway service and does not have as long a range as the style "L" signal. It utilizes two 110 volt 25 watt lamps for each light unit.

Switch Indicators: Switch indicators are of various types and styles. The ordinary practice is to reproduce the high signal indications in miniature form at main track switches where trains pull out of sidings onto the main track without having some other means of knowing whether any other trains are approaching. Semaphore indications are given by two positions of the blade, these showing whether or not it is safe to throw the switch and occupy the main track. In addition to semaphore indicators providing various aspects, there are disc indicators and light indicators.

RELAYS

The relay, being the means of detecting track occupancy by a train, must be as nearly perfect as human ingenuity can devise and careful attention to manufacture and test can insure. The direct current relay is an electro-magnet, the armature of

which carries the contact fingers, working between front and back contact posts. The alternating current relay most commonly used is of the vane type. The movement of its rotating member, which is an aluminum vane, is secured by means of induction due to energization by form wound coils placed about a magnetic circuit made up of "U" shaped punchings.



Left—Model 13 Direct Current Relay
Right—Style SLV-13 Vane Type Alternating Current Relay

Relays used in railway signal work are constructed entirely different from those in other lines, because it is essential that they *always* function properly in the control of signals governing railway traffic. The iron used must be of the very best quality and pass rigid tests. Current carrying parts of the relay must after assembly stand a break-down test of at least 3,000 volts. The materials used for contact parts are specially treated to provide long service and not fuse in case of lightning, or other high voltage or high current discharge.

Space does not permit a description of the many other detail points which are required to make up a complete signal system. The location and use of switch circuit controllers, switch indicators, battery and relay housings, insulated joints; as well as the running and connecting line wires require the use of standards developed by the railways concerned, or as adopted by the Signal Division of the American Railway Association.

AIR BRAKE DEVELOPMENT COINCIDENT WITH TRANSPORTATION REQUIREMENTS

W. H. Beattys, Jr., '99,
Representative, Westinghouse Air Brake Co., Chicago

ENERGY VALUES

The well-known principle of mechanics known as the conservation of energy is generally understood in its broader applications but is not always recognized when considering the deceleration of moving vehicles by braking, otherwise its importance in this field would be more appreciated due to the enormous energy values involved, especially in modern steam railroad practice.

Air brakes are usually considered exclusively as a safety feature of railroad operation and of relatively minor importance in determining transportation limitations as compared with the locomotive by means of which the energy is accumulated in the moving train, but which must be dissipated during the deceleration period. A true appreciation of the energy conservation principle above mentioned, however, emphasizes the equality of energy values accumulated during acceleration with those dissipated during the decelerating period.

An average modern passenger train of twelve steel coaches with locomotive and weighing approximately 930 tons, will, when operating at 80 miles per hour, be found by the application of the well-known formula $E = \frac{WV^2}{2g}$ to have accumulated a kinetic energy of approximately 197,600 foot tons, an amount sufficient to raise the entire train 212 feet above the rails or a one ton projectile approximately 37.4 miles in the air.

Under test, a train 1,040 feet long, running at 80 miles per hour, and of approximately the weight above mentioned, has actually been stopped in a distance of 2,197 feet. Assuming this deceleration to have been uniform, work was performed during the decelerating period at the rate of 19,100 horse power, whereas only 2,970 horse power was necessary in locomotive capacity to pull this train at the above mentioned speed, assuming 15 pounds per ton retarding force due to friction and wind resistance.

If this train had been allowed to come to rest without braking power on level track, assuming 10 pounds per ton as the average retarding force existing due to the above mentioned elements, it would have traveled over 28,300 feet or approximately five miles.

Should traffic conditions demand that all trains considered under proper control capable of stopping within a distance corresponding to the above emergency test stop (viz., 2,197 feet) the twelve car train under consideration, without brakes, could not operate at a maximum speed exceeding 18 miles per hour and comply with these requirements. The limitations imposed upon the speed of travel and tonnage capacity on steam railroads under such conditions can easily be imagined, and forcibly indicates the position of primary importance which the air brake bears to the whole transportation problem.

Therefore it is only necessary to mention the rapid development of railroad equipment both as to length of train and weight of the individual unit, together with increase in schedule speed, to impress even the casual observer with the necessity for continual development of air brake equipment to meet the constantly increasing demands of the rolling stock which it must safely and flexibly handle, since it is only by proper control that the heavier modern equipment could become a commercial and operating possibility.

HISTORICAL

The principle of retarding vehicles by frictional resistance dates back to earliest history, but one of the first records of a brake shoe applied to a vehicle operating on a rail is found in the year 1630 when a Newcastle coal mine operator, having laid wooden rails on which to run his mine cars, found it necessary to apply primitive brake shoes to the wheels of the equipment in question.

With the coming of the steam locomotive, various types of brakes were employed, beginning with a friction drum on the locomotive winding up a cable extending throughout the train and applying the brakes, this method being replaced at later periods by mechanical power employing steam, vacuum and compressed air mediums of operation, with the result that today compressed air occupies the field to the practical exclusion of all others.

Certain railroad lines abroad, however, operating short trains and light equipment, still employ the vacuum brake in spite of

its limitations, one of which is the fact that only one atmosphere, or 14.7 pounds, is available for braking purposes, whereas pressures from 70 to 110 pounds are standard in American railroad practice.

DECELERATION FORCES

In considering the deceleration of moving vehicles, two forces must be given consideration, viz., that between the wheel and the rail and that between the wheel and the brake shoe. The co-efficient of sliding friction being less than rolling friction, care must therefore be exercised in brake applications to prevent wheel sliding, otherwise the retarding force is lessened. Therefore the product of the weight on wheels and co-efficient of friction between wheel and rail must not exceed the product of brake shoe pressure and the similar coefficient between wheel and brake shoe.

Since without wheel sliding, pure rolling friction exists between wheel and rail regardless of speed, this coefficient remains constant for any given condition of rail, but may vary widely with change of this factor.

The coefficient of friction between brake shoe and wheel is a widely fluctuating quantity depending on materials in contact, pressure applied, duration of application, and temperature involved. Consequently, a satisfactory braking system must among other things be capable of flexible application to conform with variation in speed, existing rail conditions, brake shoe friction, etc.

THE STRAIGHT AIR BRAKE

The application of air for braking purposes as at first adopted was in the form known as the Straight Air Brake invented by George Westinghouse in 1869, which is in common use today in the electric traction field for single car city service.
the brake valve (which is practically a three-way cock) to the brake cylinder for brake application, and exhausted from same to atmosphere, when brake valve is returned to release position. While this brake is eminently satisfactory for single vehicle operation, its shortcomings are quickly noted when train operation is attempted, these limitations being—

1. Loss of all braking power on all vehicles should hose line part or any of the piping in the system break or develop extreme leaking.
2. Impossibility of obtaining simultaneous or even approxi-

mately simultaneous braking power on the different vehicles composing the train, due to the fact that the maximum retarding power will be developed in vehicles at the head end before the necessary air will be available at the rear of the train for braking purposes—this is a matter of extreme importance, which will be described in detail later.

3. The practical impossibility of storing air on locomotive in sufficient volume to properly apply brakes on trains of any considerable length.

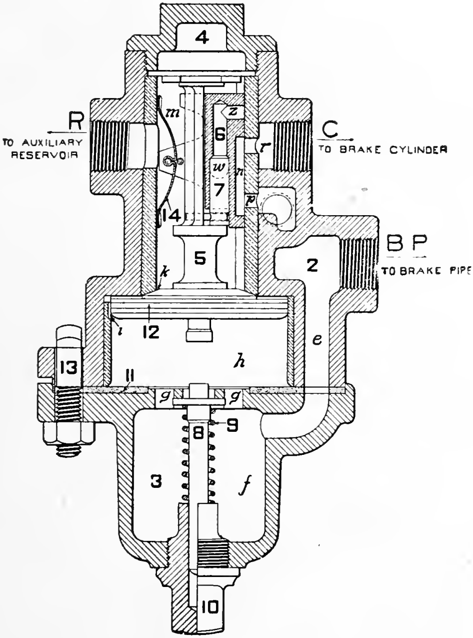


Figure 1.

THE AUTOMATIC AIR BRAKE (Plain Triple Valve)

The limitations of the straight air type becoming quickly apparent, the Automatic Air Brake, which forms the basis for all modern equipment, was developed in 1872, also by George Westinghouse.

The particular feature of this system as first developed was

a device now known as the plain triple valve which permitted each car to store air in its individual reservoir for braking purposes, which air was generated and stored in the main reservoir on the locomotive from whence it was distributed throughout the train, charging auxiliary reservoirs above referred to during the period when brakes were released.

The advantages realized by this system in overcoming the inherent objection to the straight air brake are—

1. Rupture of brake pipe, instead of causing loss of braking power on the whole train, causes automatic emergency application of brakes.
2. Each vehicle being provided with air for individual brake operation insures more nearly uniform and prompt application of brakes.

Since one of the primary functions of the air brake is to operate as a safety device, the inherent value of the automatic over the straight air type as a protection under brake pipe rupture conditions, is immediately apparent.

The plain triple valve above mentioned is shown in diagrammatic section (Fig. 1) and is so designated from the three functions which it performs· (first) connects auxiliary reservoir with brake pipe for charging purposes; (second) connects auxiliary reservoir with brake cylinder for brake application; (third) connects brake cylinder with atmosphere for releasing.

Referring to Figure 1, this device will be found to consist essentially of a piston 12 to which is attached a stem 5, provided with two collars between which is located slide valve 6 with which the collars engage, but with a certain amount of lost motion between; also graduating valve 7 which is attached to the piston stem.

Figure 2 illustrates a typical train equipment with the plain triple valve installed together with the supplementary air brake equipment, consisting of steam-driven compressor placed on the locomotive which stores compressed air in the main reservoir, from whence it is in turn admitted, by means of the engineer's valve, to the brake pipe which runs throughout the train.

When air is admitted to this brake pipe, pressure is transmitted to chamber "h" on the face of piston 12 (Fig. 1) in each triple valve throughout the train, forcing it to position shown, which is that of releasing brakes and recharging auxiliary reservoir on each car. At the same time leakage groove "i" is uncov-

ered, joining chambers "h" and "m," the latter of which at all times connects directly with the auxiliary reservoir, thus permitting equalization of same with brake pipe pressure. In the release position of the triple valve, brake cylinder pipe "C" is also connected through port "n" in the slide valve to port "p" and exhaust, as shown, thus releasing the brake.

When brake application is desired, a reduction in brake pipe pressure is made by the engineer exhausting same through the brake valve, which reduction becoming effective throughout the train, is made more rapidly than air in each triple valve can flow from chamber "m" back through feed groove "i" to chamber "h," thus creating a differential pressure between the two sides of piston 12, causing it to move downward, which, with its first movement, will close feed groove "i," cutting off communication between chambers "m" and "h."

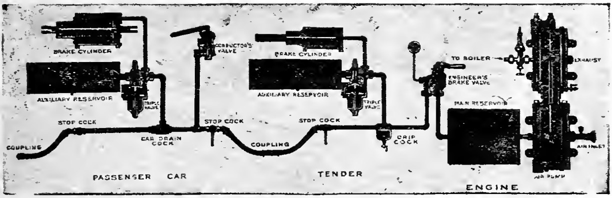


Figure 2.

As the piston continues its movement downward, graduating valve 7 unseats port "w" connecting chamber "m" with service port "Z" and then, as collar on the end of piston stem engages with slide valve 6, same is carried downward until service port "Z" registers with brake cylinder port "r", thus connecting auxiliary reservoir with the brake cylinder and applying the brakes.

Since chambers "m" and "h" are no longer connected through feed groove "i", no communication exists between brake pipe running throughout the train and the auxiliary reservoirs or brake cylinders on each car, with the result that each car inherently provides its own braking power, although previously furnished with same from a central source of compressed air installed on the locomotive.

After a definite brake pipe reduction has been made for a brake application, air flowing from the auxiliary reservoir to the brake cylinder will lower pressure in this reservoir and chamber "m"

to a point slightly below the reduced brake pipe pressure in chamber "m" to a point slightly below the reduced brake pipe pressure in chamber "h", consequently piston 12 will again be moved upward until graduating valve 7 seats and closes cavity "w" connecting with port "Z", thus cutting off connection between auxiliary reservoir and brake cylinder which prevents further application of the brake.

The triple valve is now in lap position where no further increase in brake cylinder pressure is obtained, but braking power already existing is maintained. Should additional braking power be required, brake pipe must be further reduced by the manipulation of the engineer's brake valve, causing piston 12 to again move downward connecting auxiliary reservoir with the brake cylinder, as previously described, thus providing graduated application of braking power as may be desired.

Continued reduction in brake pipe pressure with corresponding increase in braking force can be obtained until auxiliary reservoir and brake cylinder have equalized in pressure, beyond which point additional brake pipe reduction produces no further increase in braking power, but on the other hand, creates the very undesirable condition of increasing the time required to release the brake due to the larger amount of air necessary to again raise brake pipe pressure to the point where triple valves can be released.

If the length of the train is such that the increase in brake pipe pressure is very slow, certain triple valves with leaky or sticky pistons may permit the air to leak by without responding to this increase in brake pipe pressure, in which case the brakes on this particular car will remain applied, creating the condition known as "stuck" brakes. This possibility indicates the necessity for rapid rise in brake pipe pressure to insure the return of all triple valve pistons to release position if prompt and certain release of all brakes in the train is to be obtained.

When an emergency application of brakes is desired, a more rapid reduction of brake pipe pressure is created and piston 12 moves to its extreme downward position, compressing graduating spring 9 and connecting auxiliary reservoir to brake cylinder past the end of slide valve and through port "r", which is no longer restricted by the area of port "Z", and hence more rapid rise in brake cylinder pressure is obtained.

It is to be noted in this connection that the maximum pressure

which can be obtained is that of equalization between auxiliary reservoir volume and brake cylinder volume, either by emergency application or continued graduated service applications, the only difference being that emergency application is obtained in a much shorter period of time.

While graduated application of brakes is obtained by successive reductions in brake pipe pressure, it is not possible, with the plain triple valve, to obtain similarly graduated release due to the fact that when brake pipe pressure has been raised to the point necessary to return triple valve piston 12 to its full release and recharging position, there is no higher pressure behind this piston to cause return of same from full release to lap position should the brake valve be placed in lap position and further rise in brake pipe pressure be prevented. Consequently, when release of brakes has once been initiated by raising brake pipe pressure, this action will continue until full release has been obtained without the possibility of retaining partial brake cylinder pressure necessary to obtain graduated release.

When the automatic air brake employing the plain type of triple valve above described was invented, light weight rolling stock and comparatively short trains were employed in railroad operation with correspondingly short brake pipe and relatively small amount of air required for satisfactory braking, for which conditions the equipment in question was entirely adequate. With the development of heavier motive power, however, larger cars operating in trains of increasing length became possible and certain limitations of the plain triple valve became evident.

Thus, with a brake pipe of considerable length made necessary by modern freight train operation, a reduction in brake pipe pressure at the locomotive became immediately effective at the head end of the train, causing brakes to apply at that point before any such decrease became effective at the rear, due to inertia of air and friction in the long train pipe. Consequently, cars at the latter point, being still without braking power, were caused to run in violently, taking up slack throughout the train and producing severe shocks. Meanwhile the reduction in brake pipe pressure then existing at the front end caused a rush of air from the rear toward this low pressure point, which in turn resulted in lowering the air pressure at the rear, causing application of brakes at that point and again raising brake pipe pressure at the head end sufficiently to release head end brakes.

The effect of this forward surge of air in the brake pipe was to anchor the rear end of the train while causing the head end to run out with such violence that in many cases the train was parted. The action just described becomes more pronounced and the effects more disastrous with increasing length of train and severity of brake application and was therefore most apparent when emergency application of brakes was attempted, especially at comparatively low speeds where the brake shoe coefficient of friction reaches a maximum.

The link and pin coupler universally employed in railroad operation at this period also greatly aggravated the severity of slack running in and out, due to the large amount of lost motion in this type of apparatus.

Special tests of fifty-car freight trains were held on the Chicago, Burlington & Quincy Railroad in 1886, at which time the shortcomings of the plain triple valve were so decidedly demonstrated that a sevond series of tests was made the following year, during which an improvement in the form of what is known as the serial quick action feature was incorporated in triple valve construction.

This improvement consisted in causing a small but definite reduction in brake pipe pressure at each triple valve during emergency application of brakes by locally exhausting the brake pipe momentarily to brake cylinder, thus insuring the quick transmission of brake pipe reduction serially throughout the train and obtaining prompt brake application at the rear, thereby minimizing the dangerous slack action and brake kick-off at the front end, as previously described, by providing brake application on all cars before it could occur.

The quick action feature being obtainable in emergency application only, additional provisions were later found necessary to protect in service applications at which time the so-called quick service feature was also incorporated in triple valve construction, providing a similar momentary exhaust of brake pipe to brake cylinder at each triple valve, but in lesser amount than the serial quick action obtained in emergency applications, yet sufficient to assist in prompt transmission of brake pipe reduction throughout the train.

THE MODERN FREIGHT TRIPLE VALVE

Figure 3 illustrates in diagrammatic section a modern quick action, quick service triple valve used in freight service in its

release and recharging positions. The equalizing piston, which in the case of the plain triple valve illustrated in Figure 1, was shown operating vertically, is here shown in an horizontal position as piston 4 with its attached slide valve and graduating valve.

SERIAL QUICK ACTION

The serial quick action feature just mentioned is obtained under emergency conditions, at which time triple valve piston 4 has been moved to the extreme right, seating against its gasket, completely compressing graduating spring 22 and effectually sealing chamber "f" from chamber "h", in which position the aux-

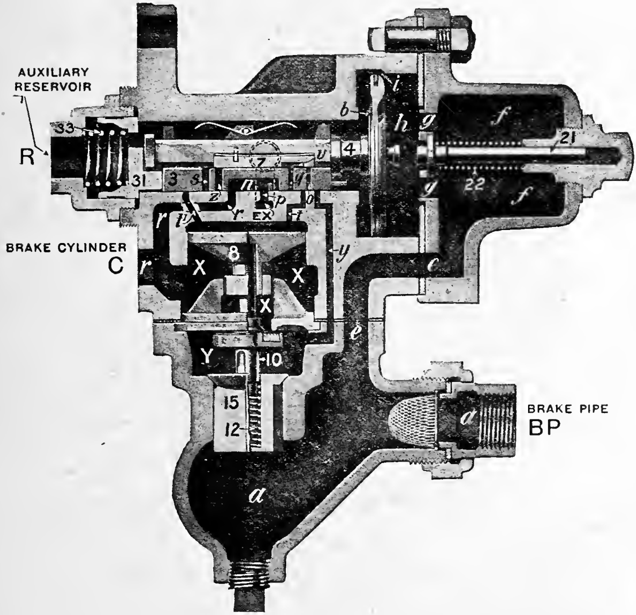


Figure 3.

iliary reservoir is connected to the top of emergency piston 8 through port "t", forcing same downward, unseating emergency valve 10 and permitting air from chamber "Y" to exhaust instantaneously through "X" to brake cylinder, the reduction of pressure in chamber "Y", thereby lifting check valve 15 and permitting brake pipe air to likewise exhaust momentarily through

chambers "Y" and "X" to brake cylinder, until pressures in "a" and "Y" have approximately equalized, at which time check valve 10 is forced to its seat, preventing brake cylinder pressure from escaping back into brake pipe.

The emergency valve 10, which is held open by emergency piston 8, will also return to its seat when auxiliary reservoir and and brake cylinder pressures have nearly equalized. Only a small but definite amount of brake pipe air has been exhausted from chamber "a" to the brake cylinder during this action, for at the same time the auxiliary reservoir has been equalizing with the brake cylinder in emergency application of brakes through ports "s" and "r", which register properly when in emergency position, just as described in the operation of the plain triple valve illustrated in Figure 1.

QUICK SERVICE

The quick service feature previously mentioned is obtained in service application only, under which conditions triple valve piston 4 has been moved to the right sufficiently for stem "h" to engage with the stem of graduating spring 22, but without compressing same, in which position air from the auxiliary reservoir flows through ports "Z" and "r" to brake cylinder, which ports, however, only partially register but allow sufficient opening to permit auxiliary reservoir pressure to fall at the same rate as brake pipe pressure in trains of considerable length.

At the same time the movement of the graduating valve on top of the slide valve has connected the two ports "o" and "q" through the graduating valve cavity "v" and the further movement of the slide valve in passing to service position has caused port "o" to register with port "Y" and port "q" with port "t". Consequently, the air in chamber "Y" flows through ports "Y", "o", "v", "q" and "t" to the top of emergency piston 8, which, fitting loosely in its cylinder, permits this air to leak past to chamber "X" and to brake cylinder without movement of same.

When the pressure in chamber "Y" has reduced below brake pipe pressure remaining in "a", the check valve 15 is raised, permitting brake pipe air to flow past this check valve and through the ports above mentioned to the top of emergency piston 8, thence to "X" and brake cylinder. The size of these ports is so proportioned that the flow of air from the brake pipe to the top of emergency piston 8 is not at a sufficient rate to force this piston downward, which would cause an emergency application, but

at the same time a definite reduction in brake pipe pressure is made in the first triple valve, which in turn is transmitted progressively to succeeding triple valves, increasing the rapidity of brake pipe reduction throughout the train and insuring prompt and certain application of the brakes.

With short trains, having comparatively small brake pipe volume, a certain reduction at the engineer's brake valve will cause a more rapid reduction in brake pipe pressure than with a longer train. In fact, this reduction might become so rapid that the "quick action" feature, instead of the "quick service" feature, would become operative and an emergency application of brakes be obtained when only service application was intended.

This is automatically prevented in the triple valve illustrated by the more rapid reduction in brake pipe pressure at the head end of the train, causing piston 4 to move slightly past service position and slightly compressing graduating spring 22, which is known as "'full service" position and in which port "Z" is caused to register fully with port "r" so that auxiliary reservoir pressure is depleted more rapidly, corresponding to the more rapid reduction in brake pipe pressure obtained with short trains and again preventing movement of emergency piston and obtaining of emergency application where service only is intended.

Since both quick action and quick service features are obtained by exhausting brake pipe to brake cylinder, a slight increase in brake cylinder pressure is possible in emergency above that in the plain triple valve first described, where equalization between auxiliary and brake cylinder reservoirs constituted the maximum brake cylinder pressure either in service or emergency.

In releasing brakes on long freight trains trouble is often experienced in the form known as "stuck" brakes, as previously described, in which case brakes remain applied and must be released locally, thus causing vexatious delays or rough handling of trains.

The amount of air required to simultaneously recharge a long train pipe and a large number of auxiliary reservoirs is very considerable and it is self-evident that the brakes at the head end of the train, being first to respond to the rise in brake pipe pressure, will be released first and begin recharging the corresponding auxiliary reservoirs, thus tending to make more difficult the transmission of air pressure to the rear of the train.

UNIFORM RELEASE AND RECHARGE

In order to equalize these recharging conditions, the so-called "uniform" feature has also been incorporated in the modern freight triple valve illustrated in Figure 3, advantage being taken of the friction in the brake pipe, which causes pressure to build up more rapidly in chamber "h" of the triple valve at the head end of the train than in those at the rear.

If the rate of brake pipe pressure rise is sufficiently rapid in the first triple valve, release piston 4 is forced to the extreme left, slightly compressing retarding spring 33, in which position brake cylinder exhaust in these triple valves is somewhat retarded by the partial restriction of exhaust port "p" by tail piece on cavity "n". By thus retarding brakes at the head end of the train, where more prompt release is normally obtained, an approximately simultaneous release of brakes throughout the train is obtained, with consequent smoother handling and more satisfactory stop.

Furthermore, since brake pipe pressure at the head end of the train rises more rapidly than at the rear, and the tendency is to build up auxiliary reservoirs more quickly and to a higher pressure at that point, more uniform recharging is obtained throughout the train by partially restricting the charging groove "i" when the triple valve piston is in the uniform release position and retarding spring 33 under compression as previously described, thus permitting a greater proportion of brake pipe air to be transmitted to the rear of the train for release and recharging purposes.

The necessity for prompt application of brakes throughout the train has been previously described, as well as the operating difficulties attending if proper conditions do not obtain. The necessity for uniform release and recharging is fully as important in its effect on train operation. Should release of brakes on a long train be attempted at comparatively low speeds, the reduction in brake pipe air becomes immediately effective at the head end of the train, tending to release and recharge, while the brakes at the rear still remaining applied, allow slack at the head end on released cars to run out severely with possible parting of the train. These conditions are greatly ameliorated by the uniform recharging and release features just described.

GRADE OPERATION

While not generally realized, proper control of freight trains

on mountain grades constitutes the most difficult condition which brake operation is called upon to handle. No doubt the general supposition is that the brakes, having once been applied to the proper degree for maintaining the desired speed in descending a grade, require no further manipulation. As a matter of fact, the opposite is the case for the reason that if the brakes were left continuously applied for any length of time,.brake pipe, as well as brake cylinder leakage throughout the train would soon deplete the brake cylinder pressure to a point where the train would no longer be under control.

Since it is then necessary to completely release the brakes for recharging and reapplying, a runaway would result. Consequently the standard method of controlling a train descending a grade is to manipulate the brakes through a definite cycle of operations in which the brakes are first applied to a definite value, allowed to remain thus for a definite time, and then released and recharged, the train being retarded as much as possible during the recharging period by the locomotive brakes and retaining valves attached to each brake cylinder, which, however, can only perform a small portion of the work necessary. As a consequence the train increases in speed during a recharging period, but not in sufficient amount to cause an excessive speed, which cannot again be reduced to the desired minimum when brakes are reapplied, provided the proper cycle of operations is employed.

This cycle of operations must therefore be of such a nature that the brake pipe depletion occurring during the braking period will not reach such a value as to require too long a time for recharging during the release portion of the cycle.

On very long grades also it is sometimes necessary to bring the train to a complete stop in order to allow proper cooling of wheels and brake shoes which have attained very high temperatures, due to the large amount of energy being dissipated thereby.

EMPTY AND LOAD BRAKE

It is possible to vary the braking pressure obtainable at the brake shoe from any given size of brake cylinder by a corresponding change in the brake leverage, consequently the correct design requires such proportioning that proper shoe clearance will be obtained without excessive piston travel.

If the shoe pressure desirable with loaded cars were installed, the percentage of braking power then obtainable when the car was operating light would be excessive, causing wheel sliding.

A compromise is therefore necessary in the proportion of brake rigging for freight service so that cars under full loaded condition must be braked somewhat lower than the desired maximum.

Under the particularly severe conditions of mountain grade work, this becomes a matter of considerable importance, which has been remedied by the use of the so-called empty and load brake, this being essentially the standard brake equipment, but with the addition of a second brake cylinder, which may be placed in operation under load conditions only.

Assurance of the load cylinder operation being obtained exclusively under the desired conditions is guaranteed by an arrangement requiring the brakeman to turn a lever on each car, throwing into service this cylinder, which is, however, automatically returned to the non-operating position required for empty conditions when the brake pipe has fallen to within a few pounds of atmospheric pressure. This insures that cars equipped with empty and load brakes, when placed on a siding, will automatically cut out the load cylinder, and hence can never be placed in trains with this functioning unless again turned up by the brakeman. This automatically prevents the skidding or locking of wheels which would occur should such a car be inadvertently placed in a train in empty or light load condition with the load cylinder functioning.

PASSENGER BRAKE EQUIPMENT

During the early stages of air brake development, freight and passenger service requirements were such that the same type of brake was considered suitable for both, but with increasing weight and length of passenger equipment and a great advance in operating schedule speeds, modern service conditions also required a flexibility and smoothness of operation not necessary in freight service where the limitations are protection of equipment against damage, rather than the comfort of the traveling public.

Furthermore, the modern freight triple valve above described does not provide substantially greater brake cylinder pressures in emergency than in service, a shortcoming which did not permit proper safety of passenger train operation with the increasing weights at higher speeds and operating on a much closer headway.

More braking power was evidently necessary to properly control these trains and the simplest way to obtain same was by increasing brake pipe pressure, thus giving higher auxiliary

reservoir pressure for brake application purposes. The use of this higher pressure was feasible only under certain conditions of high speed, providing brake cylinder pressure was properly reduced coincident with speed reduction, otherwise sliding wheels would result, due to increase in coefficient of friction between brake shoe and wheel with reducing speed.

HIGH SPEED REDUCING VALVE

This was accomplished by the introduction of the high speed reducing valve which permitted maximum brake cylinder pressure to be applied at high speeds, but quickly reduced to lower values by blowing through a properly varying restricted port, somewhat approximating the reduction in pressure desired for the corresponding reduction in speed.

GRADUATED RELEASE

Another limitation of the triple valve as developed up to this time was the impossibility of obtaining graduated release of the brakes which became increasingly important as modern service required not only safety but comfort for the traveling public.

Previous mention has been made of the inability to obtain this feature, due to the lack of any higher pressure back of triple valve piston, tending to return same to lap position when increase in brake pipe pressure for releasing brakes was stopped before full value was obtained, due to lapping of the engineer's brake valve. Accordingly an improved type of triple valve for passenger service was designed, which provides not only the graduated release desired, but also quick recharging and high pressure in emergency, all of which are obtained by the use of an additional or supplementary reservoir on each car, which, during release, is charged through the triple valve to full brake pipe pressure simultaneously with the auxiliary reservoir.

This supplementary reservoir, however, being used in emergency applications only, remains charged to full brake pipe pressure, regardless of reduction in brake pipe and auxiliary reservoir pressures obtained during service application, but by adding, in emergency applications, its volume at full pressure to that of the auxiliary reservoir greatly increases brake cylinder equalization pressure. Likewise, in release position the auxiliary and supplementary reservoirs, being then connected through the triple valve. the pressure remaining in supplementary reservoir

is available to assist brake pipe in prompt releasing of brakes and recharging auxiliary reservoirs throughout the train.

When partial or graduated release was desired, only a slight increase in brake pipe pressure was made, returning triple valve to release position, in which supplementary and auxiliary reservoirs, beginning to equalize, increased pressure behind triple valve piston to the point where this pressure was higher than corresponding brake pipe pressure existing at that time, thus moving triple valve piston back toward application position to a point known as graduated release lap, closing feed groove "i" and closing brake cylinder exhaust, thus retaining the remaining brake cylinder pressure until another graduation was obtained by another increase in brake pipe pressure, where the process was again repeated. Successive graduations were thus obtainable up to the full release of the brake, thereby providing the smooth handling of trains necessary for passenger service.

This triple valve is provided with a safety valve preventing excess pressure being obtained under service conditions, which safety valve is disconnected in emergency application.

THE UNIVERSAL VALVE

While the special form of triple valve for passenger service just described most nearly fulfilled existing requirements, it was realized that the continued changes in rolling stock, both as to weight of individual units and the number of units handled per train, together with increased density of train operation, would in the future require corresponding changes in the brake equipment for controlling same.

Consequently the idea was conceived of building what is now known as the universal valve, having as its foundation a bracket to which all piping necessary was connected so that any changes in schedule required from time to time could be made by bolting the necessary devices to the bracket in question without disturbing piping connections. This bracket, together with the various devices bolted to same, is known as the universal valve and combines all the features of the passenger triple valve previously described, together with certain additional improvements.

One type of this valve is illustrated in diagrammatic sketch in Figure 4, detailed description of which will not be attempted in this article.

Among the features of particular value provided which are not possible with the apparatus previously described is the ability

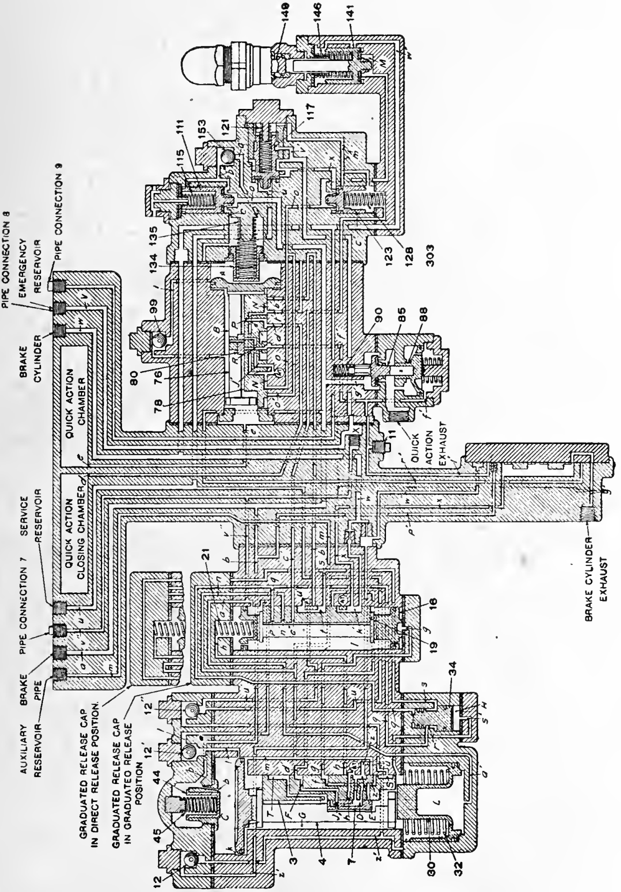

PIPE CONNECTION 8
EMERGENCY RESERVOIR
PIPE CONNECTION 9
BRAKE CYLINDER
QUICK ACTION CHAMBER
QUICK ACTION CLOSING CHAMBER
SERVICE RESERVOIR
PIPE CONNECTION 7
BRAKE PIPE
AUXILIARY RESERVOIR
GRADUATED RELEASE CAP IN DIRECT RELEASE POSITION.
GRADUATED RELEASE CAP IN GRADUATED RELEASE POSITION
QUICK ACTION EXHAUST
BRAKE CYLINDER EXHAUST

Figure 4.

to obtain emergency application of brakes at any time, regardless of service application having previously been made. It will be remembered that this is not possible in the case of triple valve operation above mentioned, except after a very light service application of brakes, for the reason that if any considerable service application has previously been made, it will then be impossible to produce sufficiently rapid fall in brake pipe pressure to cause the required differential in pressures on triple valve piston necessary to move same to emergency position.

Furthermore, since the only difference in triple valve operation between service and emergency applications is that due to the extent of travel of the equalizing piston, depending upon the rate of brake pipe reduction, it is at times impossible to avoid obtaining emergency application of brakes when only service application is desired, particularly if this piston should stick and not respond promptly to a service brake pipe reduction until such a differential has been built up between the two sides of same that when movement is finally obtained, this differential is sufficient to force piston to the extreme or emergency position.

In the universal valve, however, service and emergency features are entirely separated so that the eqalizing or service portion of the valve operates in identically the same manner under either service or emergency conditions, thus eliminating the undesired emergency just mentioned.

In Figure 4 the equalizing portion of the valve is shown at the left with its vertical piston, which fulfills the triple valve functions previously described for service application, while the quick action portion at the right provides high pressure in emergency and serial quick action, together with the additional feature of protection against depletion of the air brake system to a dangerously low point by causing emergency application of brakes when the brake pipe pressure has reduced to a predetermined minimum either through leakage or by improper operation.

The various improvements outlined thus far have been with the idea of handling the increased weight in equipment and length of trains with maximum safety and smoothness of operation. The graduated release, serial quick action, quick service, high pressure in emergency, and quick recharge features previously described all assist in bringing about this much desired condition.

To obtain the maximum safety requires that the brakes be applied instantaneously in emergency, and to obtain smooth handling likewise requires simultaneous application on all cars with the same percentage of braking power on each unit during either service or emergency applications, thus preventing any relative motion between cars or a tendency to run the train slack in or out. Inertia of air and friction in the brake pipe have been the greatest obstacles in the way of obtaining this instanstaneous action.

ELECTRO-PNEUMATIC OPERATION

It is therefore natural that we turn to electric operation of the brake actuating mechanisms to overcome this handicap, and the universal valve has been designed with this end in view. In fact, one large railroad system is at present operating several test trains equipped with universal apparatus, including the electric attachments necessary.

It is to be understood that electric operation of brakes as applied in connection with the universal apparatus does not comprehend purely electric or magnetic brakes, but merely the application of proper relay valves to each universal valve on the train for the purpose of securing simultaneous brake application by the operation of pilot valves locally, thus overcoming the time element caused by inertia and brake pipe friction previously mentioned.

That this much desired condition can be secured is borne out by tests now being made under actual operating conditions.

In the application of the electric features to the universal valve, the necessary operating contacts have been mounted on the engineer's valve directly above the corresponding pneumatic positions of same, so that in normal operation the electric contacts are made simultaneously with the corresponding pneumatic positions, but the propagation electrically throughout the train being practically instantaneous, insures that this method of brake operation will predominate, at the same time insuring pneumatic operation of the brakes should the electrical features fail at any time.

A standard universal type passenger equipment without electric features is illustrated in Figure 5, showing the relationship of the universal valve to the various other parts of the brake equipment.

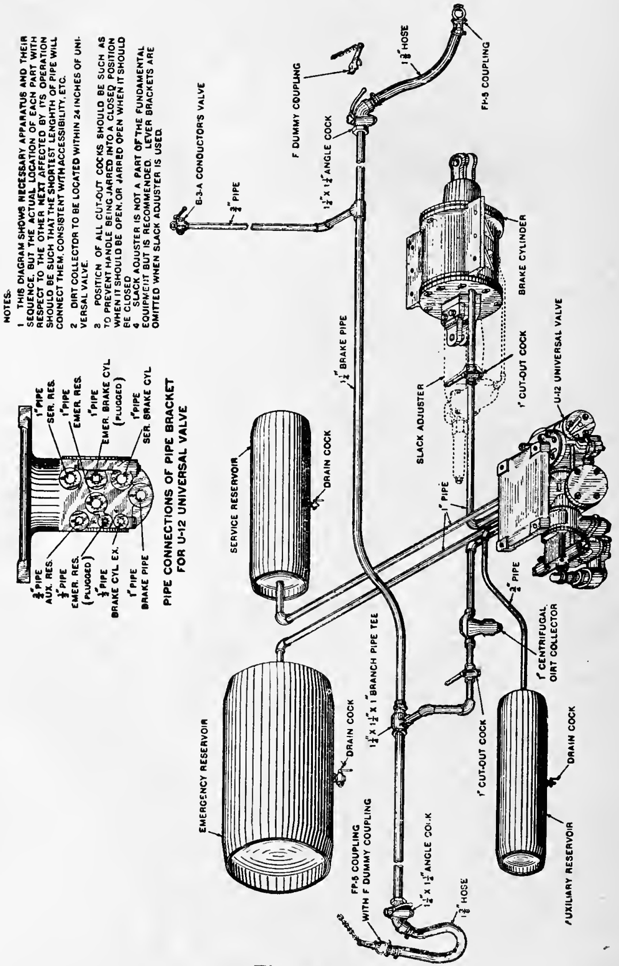

NOTES-
1 THIS DIAGRAM SHOWS NECESSARY APPARATUS AND THEIR SEQUENCE, BUT THE ACTUAL LOCATION OF EACH PART WITH RESPECT TO THE OTHER NEXT AFFECTED BY ITS OPERATION SHOULD BE SUCH THAT THE SHORTEST LENGHTH OF PIPE WILL CONNECT THEM, CONSISTENT WITH ACCESSIBILITY, ETC.
2 DIRT COLLECTOR TO BE LOCATED WITHIN 24 INCHES OF UNIVERSAL VALVE.
3 POSITION OF ALL CUT-OUT COCKS SHOULD BE SUCH AS TO PREVENT HANDLE BEING JARRED INTO A CLOSED POSITION WHEN IT SHOULD BE OPEN, OR JARRED OPEN WHEN IT SHOULD BE CLOSED
4 SLACK ADJUSTER IS NOT A PART OF THE FUNDAMENTAL EQUIPMENT BUT IS RECOMMENDED. LEVER BRACKETS ARE OMITTED WHEN SLACK ADJUSTER IS USED.
3/4" PIPE AUX. RES.
1/2" PIPE EMER. RES. (PLUGGED)
1/2" PIPE BRAKE CYL EX.
1" PIPE BRAKE PIPE
1" PIPE SER. RES.
1" PIPE EMER. RES.
1" PIPE EMER. BRAKE CYL (PLUGGED)
1" PIPE SER. BRAKE CYL
PIPE CONNECTIONS OF PIPE BRACKET FOR U-12 UNIVERSAL VALVE
B-3-A CONDUCTOR'S VALVE
3/4" PIPE
F DUMMY COUPLING
1 1/4" X 1 1/4" ANGLE COCK
1 3/8" HOSE
FH-5 COUPLING
BRAKE CYLINDER
1 1/4" BRAKE PIPE
SLACK ADJUSTER
1" CUT-OUT COCK
U-12 UNIVERSAL VALVE
SERVICE RESERVOIR
DRAIN COCK
1" PIPE
3/4" PIPE
1" CENTRIFUGAL DIRT COLLECTOR
EMERGENCY RESERVOIR
DRAIN COCK
1 1/4" X 1 1/4" X 1" BRANCH PIPE TEE
1" CUT-OUT COCK
FP-5 COUPLING WITH F DUMMY COUPLING
1 1/4" X 1 1/4" ANGLE COCK
1 3/8" HOSE
DRAIN COCK
AUXILIARY RESERVOIR

Figure 5.

CONCLUSION

Throughout this paper attention has been called exclusively to the development of the triple valve from its simplest form to the universal valve herein illustrated, for the reason that this device and its functioning constitute the real heart of the air brake problem.

Improvements have of course been made in the engineer's operating valve, in the steam-driven pumps supplying the necessary compressed air, and in the automatic governor regulating same. Throughout all this development, however, the simple principles embodied in the original plain triple valve, as invented by Mr. Westinghouse in 1875, have been the foundation for automatic air brake operation in spite of the fact that the system as a whole is in a constant state of evolution, keeping pace with the increase in operating requirements.

Brake equipment for electric traction purposes has followed somewhat along the lines of steam railroad development, differing principally in the substitution of a motor-driven air compressor for the generation of compressed air, together with an electric pressure governor automatically stopping and starting the compressor to maintain reservoir pressures within the desired limitations.

A proper conception of the necessity for continual development may be gathered from the fact that in 1875 a standard locomotive and five passenger cars, weighing approximately 75 tons, would, when operating at a speed of 35 miles per hour, represent approximately 3,060 tons kinetic energy, whereas the modern train of locomotive and twelve Pullman cars, mentioned in the introduction, and weighing 930 tons, will, when operating at a speed of 75 miles per hour, which is not unusual, have stored within it a corresponding kinetic energy of 137,200 tons, so that the work to be done by the braking system today, as compared with the earlier period, is in the ratio of 45 to 1, notwithstanding the fact that the equipment as a mechanical system of leverage remains the same in principle, although its requirements as to capacity and flexibility have of necessity been very greatly increased.

DIFFERENTIALS AND THEIR USE

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In Newton's *Principia, Book I, Section I, Lemma I,* we find the following:

"Quantities, and the ratios of quantities, which in any finite time, tend continually to equality; and before the end of that time, approach nearer to each other than by any given difference, become ultimately equal."

This lemma is proved and further on, in *Book I, Section I, Scholium,* there appears the following:

"I choose rather to reduce the demonstrations of the following propositions to the prime and ultimate sums and ratios of nascent and evanescent quantities; that is, to the limits of those sums and ratios. . . Therefore, if hereafter I shall happen to consider quantities as made up of particles, or shall use little curve lines for right ones, I should not be understood to mean indivisibles, but evanescent divisible quantities; not the sums and ratios of determinate parts, but always the limits of sums and ratios."

In the time of Newton as well as today such expressions as, *infinitely small quantities, vanishing* or *evanescent qualities, infinitesimals,* and *differentials* when used in the same sense, caused much trouble and confusion in books that deal with the application of the calculus. And, what is still more to be deplored, the same confusion exists in some present-day texts on the calculus.

The trouble can be avoided by holding to limits and finite differentials, and never using such expressions as *infinitely small quantities.* It was to avoid such ideals as much as possible that Newton introduced fluxions into his method. Newton however, did not free himself from the use of the infinitely small, though it is apparent from the reading of his writings that he was constantly endeavoring to do so. On the other hand, Leibniz used infinitely small quantities and made no effort to avoid them. Another point that is worthy of emphasis is that Newton used only infinitesimals of the *first* order while Leibniz used those of higher order as well; and it is these infinitesimals of higher order that have caused confusion to the n-th degree.

Newton in his *Quadrature of Curves* published in 1704, says: "In the method of fluxions there is no necessity of introducing figures infinitely small into geometry." It is in this work that he succeeds in almost completely excluding quantities infinitely little.

The confusion of ideas and symbols was heightened in England because the first printed treatment of the new analysis to reach that country was the work of Leibniz. He published his first ideas of differential calculus in 1684. The first book on the subject to be printed in England was by John Craig, a Scotchman. He used the notation of Leibniz and brought out his first book in 1685, and another in 1693. It is generally believed that some of the confusion at least, would have been avoided if Newton had printed his discoveries earlier. While Newton had begun to put his ideas into manuscript form as early as 1665, the first of his writings to be printed was the *Principia* in 1687.

Because of the lack of publications using Newton's notation and because the notation of Leibniz was more readily written, the English writers on the subject around 1700 used the notation of Leibniz, and they often said fluxion instead of differential while using the notation of differential. What wonder then that with all of this confusion Bishop Berkeley should say: "And what are these fluxions? The velocities of evanescent increments. And what are these same evanescent increments? They are neither finite quantities, nor quantities infinitely small, nor yet nothing. May we not call them the ghosts of departed quantities?" An echo of this was voiced by a present-day Harvard professor who referred to the differential as "that miserable little zero."

The differential method of Leibniz considers magnitudes as made up of an infinite number of very small constituent parts put together, whereas the fluxionary method of Newton considers magnitudes as generated by motion. During the early part of the eighteenth century thousands of pages were printed in discussing fluxions and differentials and the ideas connected with these terms. Here a differential was always an infinitely small quantity. This discussion tended toward clarifying the subject and, about the middle of the century in Great Britain, resulted in the production of several well-written texts on the subject. Not all the writers broke away from the use of the infinitely small quantity, but those who did were among the leaders. Maclaurin was one of these, and his Treatise on Fluxions, 1742, was in marked contrast to Emerson's Doctrine of Fluxions, 1743, second

edition, 1757, which makes liberal use of infinitely small quantities.

The following quotation from Emerson's Doctrine of Fluxions, second edition, will illustrate the view point of those who used the infinitely small quantities.

"It is the general practice in mechanics to measure the velocity of a body by the space uniformly described in a given time. . . . Now suppose a right line described with any sort of velocity, accelerated or retarded, at pleasure, and that we would inquire what is the velocity of it in any given place. If we take a small part of the line, which the moving point describes just before it arrives at that place, and call it an increment, and suppose it to be described in a very small given time, then this increment will nearly measure the velocity of the describing point at the place proposed, and is sufficient to give a vulgar notion of the degree of velocity required. Now if this right line was described uniformly, this would accurately measure the velocity. But since that increment is described with a velocity, by supposition, continually variable, therefore this motion we have here obtained is to be corrected. . . . Here then it will be very evident, if we take a still lesser and lesser increment by which the velocity is measured, as the point still draws nearer the proposed place; we approach nearer and nearer to a uniform velocity, till the difference be less than any assignable. And this increment will differ from the true measure of the velocity, by less than any given difference. And as this increment continually diminishes, till at last it vanishes, it approaches continually to that measure, till the difference vanishes with it.

"Now although by diminishing the increment at pleasure we can approach within any degree of exactness to the velocity required, yet since no increment can be taken so small, but it is still further divisible *ad infinitum;* and since the velocity is by supposition continually variable, it is plain, there can be no two points of this increment in both which the velocity is accurately the same. It is therefore most manifest, that the velocity here inquired after is peculiar to one only indivisible point; and that point is the place where the increment ends, or vanishes into nothing. Here then we see plainly, that the velocity in any given point of the line described (or, which is the same thing, that the fluxion in any given point of a generated quantity) has a certain, fixed, determinate value, proper to that point of it alone. . . .

"Here a metaphysical disputant may demand, how it comes to

pass, that any velocity which *continues* for no time at all, can possibly describe any space at all; or whether its effect is absolutely nothing, or an infinitely small quantity, or what it is. Here then it is, that our reason is at a stand, and the human faculties are quite confounded, lost, and bewildered. We are puzzled and perplexed by endeavoring to examine into the nature of we do not know what, nor whether it is something or nothing. . . ."

Continuing to much greater length, but with the same method of argument the author finally says: "And if any one should doubt the truth of this, I should forever despair of convincing him of anything at all."

The abandonment of the infinitely small quantity in Great Britain during the eighteenth century added to the clearness and the logical rigor of mathematics. While this treatment was mainly geometrical its rigor was far in advance of that of the Continental writers on the same subject.

One of the perversities in historical events is exhibited in the fact that after infinitely small quantities had been so largely expelled from England in the eighteenth century as unreal and confusing, they should return again in the nineteenth century and flourish as never before. This is strikingly illustrated in the use of the infinitesmal (the infinitely small) in Price's large work on the *Infinitesimal Calculus*, 1860, a work which in many ways is most admirable.

STATE OF MATTERS AT PRESENT

That the question of differentials is alive at the present time is evidenced by the fact that it was recently a subject for discussion by the Society for the Promotion of Engineering Education.*

As illustrations of the confusion in these ideas the following quotations are made from present-day text books. Some of these were given by Professor Huntington in the discussion referred to above. The date of the publication of the text quoted is given but not the name of the author.

(1) 1908. "The symbol $\frac{ds}{dt}$ is one single symbol, and is not to be treated otherwise."

*Proceedings of the Society, 1914, Vol. XXII.

(2) 1903. "The symbol $\dfrac{dy}{dx}$ does not denote a fraction; it does not mean the ratio of a quantity dy to a quantity dx. It must be clearly understood that the cancellation of the dx's in the equation

$$dy = \frac{dy}{dx}\,dx$$ is impossible."

(3). 1897. "If $f'(x)$ is the derivative of $f(x)$ with respect to x, then $\Delta y = (x)\Delta x$ becomes more and more nearly true as Δx approaches the value 0, this is not in the sense that both vanish but in the sense that the ratio of the two sides approaches the value unity. In this artificial sense the equation is often written $dy = f(x)\,dx$. The vanishing quantities dx and dy are called differentials."

(4) 1901. "When the *increment*, or *difference*, is supposed *infinitely small*, or an *infinitesimal*, it is called a *differential*. It may also be defined as the difference between two consecutive values of a variable or function."

(5) 1903. "The independent variable is supposed to change by a continued addition of an infinitely small constant increment. This increment is called the differential of the variable, and the corresponding increment of the function is called the differential of the function."

(6) 1906. "The differential of any variable quantity is an infinitely small increment in that quantity. Thus dx is an infinitely small Δx, and dy is an infinitely small Δy."

(7) 1905. "As a matter of fact, the symbols dx, dt, etc., are constantly used in place of Δx, Δt, etc."

(8) 1914. "When Δt is *infinitely small*, that is, smaller than 0.0000000001, it is denoted by dt, and the corresponding increment of space by ds."

(9) 1903. "It will be seen that if Δl be taken large, error will be introduced, and that the error becomes small as Δl becomes smaller, and that it *disappears when Δl becomes infinitely small.* When this happy state is reached we substitute dl for Δl."

(10). 1906. "When a quantity becomes indefinitely small, far too small for human mental conception, we call it infinitely small and we write in mathematically 'O,' called nought or zero. Thus, as well as denoting what we familiarly call nothing, the symbol

O is also used to denote a quantity so small that we are unable to distinguish the difference between the quantity and nothing."

These are fair samples of the confusion into which one is led when he attempts to define a differential as an infinitely small quantity or increment. What a certain writer is going to mean by infinitely small can never be told in advance. Some writers may mean a variable increment approaching zero as its limit, and so use dy and Δy with the same meaning; others may mean a constant magnitude negligibly small, and so abandon all claim to accuracy in their results; while others may mean a flat zero, or else one of those relative zeros, which at the same time exist and do not exist, one of those "ghosts of departed quantities."

FUNDAMENTAL IDEAS OF THE CALCULUS

Any one who has occasion to apply mathematics realizes the importance of clear, clean-cut ideas, and the great advantage of having ideas that can be visualized or connected up with real things. It is too often the case that a student may finish the study of the calculus and not realize in any very clear manner just what it is that he has been dealing with.

Quantities and numbers dealt with in arithmetic and algebra are such as, in general, do not vary, and no scheme is developed there for handling questions that have to do with rates of change of quantities.

Differential calculus is particularly concerned with the *rate of change* of any quantity which changes or varies. Methods are here developed for finding the rate of change of a varying quantity, and for handling questions that can be answered by means of this rate of change. As a mathematical subject differential calculus expresses these ideas in symbols and deals with them in a definite and precise fashion that is a great saving of time and mental energy. When we say that Newton and Leibniz invented calculus, we mean that they invented the symbolic treatment of the ideas involved, that is, the machinery of the subject. But the fundamental ideas of the calculus were as common before their time as after.

In scientific work and engineering one is concerned very largely with quantities that vary. Here also the manner of variation is a consideration of primary importance.

Integral calculus deals with questions that are the inverse of those considered in differential calculus. That is, the fundamental

question in integral calculus is: Given the rate of change of a quantity and the value of the quantity at some certain instant to find the value of the quantity at any instant.

DIFFERENTIAL DEFINED

When two variables are so related that the ratio of their corresponding increments is *constant*, either variable is said to change *uniformly* with respect to the other. The time that a man works and the pay that he receives are two such variables.

If two variables are so related that one is dependent and the other is independent, then for corresponding values of the variables:

(1) The *differential of the independent variable* is the value of its increment.

(2) The *differential of the dependent variable* is what would be its increment, if at the corresponding values considered, its change *became* and *remained* uniform with respect to the independent variable.

These definitions enable one to express in the symbols of calculus many common ideas necessarily considered in life activities. For instance, when one states that an automobile is moving at 30 miles an hour, he means that, if at the instant of observation the speed should become and remain uniform for the ensuing hour, it would go a distance of 30 miles. Of course if the increment (differential) of time were taken less, the differential of the distance would be less. In fact, it is usual to consider differentials as comparatively small numbers, but they should not be considered "infinitely small." If they are always considered as definite quantities, though perhaps small, one finds it possible to visualize them readily, and this is very important in any consideration of practical problems.

ILLUSTRATIONS OF DIFFERENTIALS

If one understands the relation of variables he is considering, and knows how they are changing, he can intuitively express their differentials at pleasure. The following are some simple illustrations:

(1) When the relation between two variables can be expressed by an equation of the first degree, as $y=mx+b$, where $\Delta y=m\Delta x$, then $\frac{\Delta y}{\Delta x}=m$. That is, either variable changes *uniformly* with

respect to the other. Then taking x as the independent variable, $dx=\Delta x$ and $dy=\Delta y$. It should be noted that $dy=\Delta y$ when, and only when, the graph of $y=f(x)$ is a straight line. (See Fig. 1.)

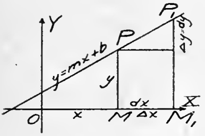

FIG 1

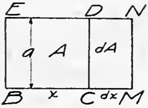

FIG. 2

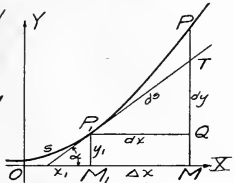

FIG. 3

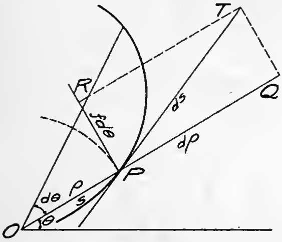

FIG. 5.

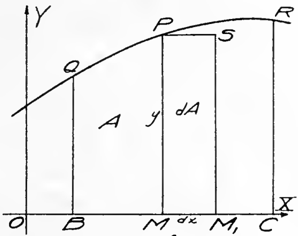

FIG. 4.

(2) If the rectangle of constant altitude, Fig. 2, is increased in area by increasing the base by the length CM, the area is increased by the rectangle $CMND$. Here evidently the area A is a function of the base x. Since A and x change uniformly with respect to each other, $CM=dx$ and the rectangle $CMND=dA$.

(3) Consider the curve $y=f(x)$, Fig. 3, as being traced by a point moving to the right and upward. The direction that the tracing point is moving at any point is along the tangent line at that point. Let (x, y) be the coördinates of the moving point. Evidently y is changing non-uniformly with respect to x. Suppose that the moving point has reached P_1. Here y is evidently changing at the same rate it would if the point were moving along the tangent line at P_1. If then the change in y is to *become* and *remain* uniform with respect to x, the point must move along the tangent.

It follows that at the point P_1, if the increment of x is

$\Delta x = M_1M$, $dx = \Delta x$, and $dy = QT$. It is to be noted that the corresponding increment of y is $\Delta y = QP$.

Again, if s is the length of the curve traced from some starting point, then corresponding to dx and dy, the change in s, if the change becomes and remains uniform, is $ds = P_1T$.

The right triangle P_1QT, called the *differential triangle*, is finite and definite, and its sides represent exactly dx, dy, and ds. It follows that $(ds)^2 = (dx)^2 + (dy)^2$.

It also follows that $\tan QP_1T = \dfrac{dy}{dx} = \tan' \alpha =$ slope of the tangent line. But from any calculus the derivative of y with respect to x, $\dfrac{dy}{dx}$, represents the slope of the tangent line. Hence the quotient of the differentials equals the derivative at any point. This is the reason why one may at pleasure replace a derivative by the quotient of the differentials.

In order not to confuse symbols, if $f'(x)$ is the derivative of y with respect to x, and $\dfrac{dy}{dx}$ is the quotient of the differentials, then

$$\frac{dy}{dx} = f'(x) \textit{ and } dy = f'(x)dx.$$

This last equation can be visualized by noting that $f'(x)$ represents the *rate* at which y is changing with respect to x at the particular point considered, and dx and dy are corresponding changes in x and y.

One should always remember that the derivative $\dfrac{dy}{dx}$ which is defined as the $\lim\limits_{\Delta x \to 0} \dfrac{\Delta y}{\Delta x}$ is a combination of symbols that must never be torn asunder, but the quotient of the differentials may be handled as any fraction as they are finite quantities, in general, not equal to zero.

It is the comparative ease with which differentials can be used

that leads the practical man to derive so many formulas by means of them. For instance, the formula for finding the length of an arc requires a long consideration by the method of limits, while it follows at once from the equation $(ds)^2=(dx)^2+(dy)^2$. For dividing by $(dx)^2$ and taking the square root,

$$\frac{ds}{dx}=\sqrt{1+\left(\frac{dy}{dx}\right)^2}. \quad \therefore \quad ds=\sqrt{1+\left(\frac{dy}{dx}\right)^2}\,dx.$$

It is this rapidity and ease with which one can derive formulas and state relations by differentials rather than by means of limits that causes them to be so much in favor. Any engineer will be well paid for time he has to spend in considering differentials so carefully that he can think readily in terms of them. This is not to be taken as an argument against the use of limits, for they are necessary in many cases for mathematical rigor.

Some further illustrations of the ease of writing differentials of variables will now be given, but because of lack of space no attempt is made to explain them fully.

(4) In deriving the formula for finding the area between a curve, the *x-axis,* and two ordinates, consider the area A as generated by an ordinate moving toward the right. When it has advanced to any value of x, $dA=f(x)dx$ is the area of the rectangle as shown in Fig. 4.

The same ideas can be readily applied to determine the differential of an area of a surface generated by a moving curve, or to the differential of the volume of a solid generated by a moving area. It can also be readily applied to finding differentials of moments for centers of gravity and moments of inertia, as well as to numerous differentials to be found in applying mathematics to chemistry, physics, electricity, mechanics, etc.

(5) Finally the differentials of the arc of a curve expressed in polar coordinates will be found. This is usually slurred over in a calculus where limits are used. Let the equation of the curve, Fig. 5, be $\rho=f(\Theta)$. If s is the length of arc generated by the moving point, then if the change in ρ and in s become and remain uniform with respect to θ at any point P, the differential of the arc, ds, is along the tangent line PT; the differential of the radius vector, $d\rho$, is along the radius vector OP; and the differential of the motion of the point perpendicular to the radius vector is $\rho d\theta$ along PR. Then it follows that when θ takes an

increment $d\theta$, $ds=PT$, $d\rho=PQ$, and $\rho d\theta=PR$.

$$\therefore ds = \sqrt{(\rho d\theta)^2 + (d\rho)^2} = \sqrt{\rho^2 + \left(\frac{d\rho}{d\theta}\right)^2}\, d\theta$$

Here then we have given some illustrations of a powerful mathematical method, or the uses of a mathematical tool, that can be used readily and with a fair degree of success. By means of it one can "get on" rapidly and can visualize the quantities concerned more easily than can be done by the method of limits; but the method of limits would seem to be necessary in many cases especially for mathematical rigor.

SCHOLARSHIP AND SUCCESS

Prof. Raymond Walters of Lehigh University has made an investigation of high scholarship and its resulting effect upon a man regarding his standing in the engineering world.

The report shows that of 392 distinguished engineers 46.4 per cent graduated in the highest fifth scholastically of their classes; 27.8 per cent in the second fifth; 18.3 per cent in the middle fifth; 3.6 per cent in the next to the lowest and 3.8 per cent in the lowest fifth.

Of 730 listed distinguished engineers 80 per cent were college graduates; 16 per cent secondary school graduates and less than 5 per cent started in college and didn't finish.

The arbitrary basis of eminence in the study of a professional group was taken to be the holding of office, membership in important committees, and service as representatives of the four founded engineering societies, civil, electrical, mechanical, and mining and metallurgy for five years 1915-1919.

WHAT DOES THE COLLEGE MAN KNOW?

By Gilbert V. Bradbury, '22*

Owing to the fact that this paper is required to be original the author will attempt to confine himself mainly to some factors that have come to his attention during his college life and acquaintance with college men.

There has been, of late, a great deal of adverse criticism of the college man. It seems that this might be eliminated to a great extent if a clearer conception existed of just what a college education was supposed to do for a man. Someone has said in effect "Send a wise man to college and he returns an educated wise man; send a fool to college and he returns an educated fool." He spoke the truth.

In these days of comparatively easy money, when the country in which we live is in its prime, so to speak, with the utilization of our natural resources at the peak, a great many men are able to attend college without the expenditure of any great effort, and without any great sacrifice on the part of their parents. Consequently, many men enter college without any definite objective in mind. They do not know what business or profession they want to follow, or are fitted to follow when they leave college. The result is not surprising: they drift.

Contrary to the Declaration of Independence, all men are not "born free and equal," except in the sense that each is entitled to strive for happiness or livelihood in any way he may desire. Men are certainly not equal as to brain capacity, and environment and breeding have a great influence upon the way in which they utilize the brains that they have. Let us take a definite case that came to the author's notice. The boy (let us call him Jones) was the son of a well-to-do business man and an indulgent mother. He always had almost anything he wanted. He came to regard a fine home, automobiles, servants, a country club and a general ease of life as a matter of course. He had been used to nothing else. Whereas his father had had to earn these luxuries by hard work and realized how hard they were to obtain, the boy grew to manhood under the impression that after he had finished his education he would, by some magic hocus-pocus, be transformed into

*Written as initiation requirement of Tau Beta Pi.

a full-fledged executive capable of commanding a salary (he named the figure) of about two hundred to three hundred dollars a month. The outcome is apparent. Either the man will have to get down to business in earnest after his college days and learn his lessons by the school of hard knocks, or else become an inefficient misanthrope who believes that he is right and the world is all wrong.

Contrast this man spoken of above when he gets out of college at the age of twenty-two, with the man of equal brain capacity who has had nothing all his life, and who, by keeping busy in all his spare time has managed to obtain a high school education. Let us call this man Smith. Smith has realized the value of education and has striven hard to get it. Having sacrificed much to get it, he has worked hard in school and has obtained a great deal more than just enough to "get by." Furthermore, he has put himself in competition in a business way with others before he has graduated even from high school. He knows what he is worth. The chances are that he has obtained more from his high school education than Jones obtained from his college education. Furthermore, at the age of eighteen he has graduated from high school and entered the field of business, and at the age of twenty-two has had four years of experience. It must also be borne in mind that he has had his experience during, perhaps, the most formative period of his life. Without going any further, it would seem apparent that Jones has a formidable opponent when he graduates, even if he has studied attentively while in college.

The college-bred man can at times show ignorance that is astounding. The author once had occasion to note some answers made by college men to the following question: How far is it around the world at the equator? Number one thought it was about 4,000 miles. Number two frankly didn't know. Number three didn't know and further volunteered the information that nobody knew. Incidentally he was studying to be a civil engineer! He said he thought Einstein might figure it out! A man who had credit for college physics guessed that light traveled at a speed of 2,000 feet a second! Estimates on the distance from the earth to the sun were appalling. One man thought the moon was 400 light-years distant!

What is at fault? Is it the student, or the institution at which he obtains his education? Before attempting to answer this question it would perhaps be well to reflect. There are many

works of mankind which lack perfection in no inconsiderable degree. Individually and collectively mankind is full of imperfections.. No doubt the colleges could turn out high-grade, almost flawless men by limiting the enrollment to men who were able to pass a very strict examination; men whose capacity and sincerity of purpose placed them in the highest rank. But would it be right to deny admittance to the rest? Would it be fair to turn away probably 60% of those who applied for entrance? Assuredly not. And, even granting that it would be right, would the economic interests of the public be better served? Probably not. Let us postpone the answer.

Within the last year, Thos. A. Edison has thrown the colleges into somewhat of an uproar by publishing his questionnaire. He has made some rather uncomplimentary remarks about college men. The strange thing was, however, that Mr. Edison placed such a great value on isolated facts. In one of the lists, however, appeared a question dealing in mechanics: A cannon-ball, weighing two hundred pounds, is dropped on an anvil from a height of two feet. What is the maximum force of compression in pounds? The author believes that this question throws some light on the difference between the college-bred engineer and the practical engineer. The question is obviously incomplete, and even if complete would occasion some mild curiosity as to just how Mr. Edison would solve it.

The aim of the colleges should be, and in the author's estimation seems to be, to ground the student in the fundamentals, and to teach him to solve his problems in an orderly rational way. We may now answer the question as to where the blame lies for the ignorance of our college men., It lies in lack of brain power. It lies in lack of incentive. It lies in lack of proper previous training. It sometimes, but not often, is due to poor instruction. Let the man who is capable of making a good brain from a poor one, who can control environment and who can make each man like his neighbor and none different from another suggest a general panacea for ignorance in college men, or any class of men. Until he arrives mankind will find it necessary to struggle along doing the best it can, and our institutions of learning will still have to attempt to do the greatest good for the greatest number.

The Armour Engineer

The Quarterly Technical Publication of the

Armour Institute of Technology

VOLUME XIII | JANUARY, 1922 | NO. 2

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Published four times a year, in November, January, March and May. Publication Office: Federal and 33rd Streets, Chicago.

TERMS OF SUBSCRIPTION.

The Armour Engineer, four issues, postage prepaid, $1.50 per annum

THE ENGINEER AND THE MUSICIAN

Is an engineering education just a preparation for a man to go out and build bridges, plan machinery, design sewers, make explosives and so forth? Is an engineer necessarily a graduate of a technical or engineering college? Is an engineer limited to what he learns in school or with engineering companies? I want to say, "NO," even if the dictionary tries to keep me from it. I want to change the meaning of the word as it is usually taken. I want to take away the limits of the engineering field. To go to extremes, what is the difference between engineering and music? You say, "Oh my!" Did you ever analyze music? You have not

or you would not say, "Oh my!" There are problems in music that are very similar to what we have been used to calling problems in engineering. A sheet of music is certainly the same in principle as the plan of a house or machine. The musical composition musts have originality of design to be a success as well as does the plan of the house. It is a fact that the fundamentals of music take a mathematical mind. Time, rhythm and harmony! Think of the composer who draws the plans of his composition. He must not violate the rules of time, rhythm and harmony. He must follow his notes around on his composition paper with just the same sort of concentration the engineer uses in the development of mechanical schemes. Think of the man who constructs the orchestration. He puts together say fifteen parts, each part to fit the proper instrument in the instrument's proper key, and all the parts to make the composition. If this is not engineering, what is it?

This comparison of the musician and the engineer is just to let the engineer know that he, too, is an artist. He, like the artist, is so interested in his work that he is content with less than the men in other enterprises. The musician, however, is getting away from this and is learning every day how to get more from his art. The engineer must learn this also. The engineer must gain the prestige that is an attribute of the other more recognized professions. There is much time wasted on details that may be picked up when needed from the proper library. In my opinion more time should be spent by the student of engineering on subjects that will broaden him. The average engineering graduate is lacking in many of the fundamental necessities to the development of personality.

We are daily hearing the sad tales of the underpaid engineer and we are given the impression that the rest of the world has it in for him. If the engineer is underpaid there is a reason and let us engineers find out this reason and correct the trouble. Let us all work at our art as the artist does, and let us forget that we are underpaid and show the people of the world that we are giving them something. The man who is continually thinking of the money he is going to get is certainly not the man who accomplishes the big things.

T. Michels.

THE ATHLETIC ASSOCIATION

Elsewhere in this issue is an account of the conception of this organization which is to be henceforth known as the Armour Athletic Association. Its purposes are there briefly outlined and additional functions are readily conceivable.

One need of our Institute is that type of advertising which will bring it before the public in a favorable light. While the creditable performances of our alumni are effective in this direction, it is a fact that athletic prominence performs the same function to a greater degree than anything else.

Another need is the creation of a bond between the constituent parts of the student body. Too many leave school at graduation only to look back over the period of their college course and see that they have missed something they might have gotten had college spirit been more in vogue. Their chance was lost.

While we are handicapped in our athletic development by the lack of time and incentive by the participants, we could, if school spirit were more in evidence, undoubtedly make a better showing than has been done in the few years past. Our enrollment compares favorably with that of other schools and need not prove a hindrance.

The function of the Association will be to provide the impetus to develop the Armour spirit, to make the student body act as *one* in the support of their team, and to provide an incentive towards participation on the team. The benefits will not be felt entirely by the school. Every individual who acquires some of this elusive school spirit will have a prized possession. Loyalty to one's own, be it family, community, organization, or whatnot, is one essential characteristic of a successful man.

Don't knock. That is only an echo of something in *your* make-up that's loose and rattling.

LET'S BOOST.

* * *

There is a kind of greatness which does not depend upon fortune: it is a certain manner that distinguishes us, and which seems to destine us for great things; it is the value we insensibly set upon ourselves; it is by this quality that we gain the deference of other men, and it is this which commonly raises us more above them than birth, rank, or even merit itself.

Have YOU ever made an effort toward making the "ENGINEER" the magazine you think it ought to be?

The ENGINEER is published for the Armour alumni.

The ENGINEER is published for the Armour students.

The ENGINEER needs the co-operation of *every one* of its readers to make it "fill the bill." It needs criticism. It needs suggestions. It needs material to make the College Notes and Alumni News interesting. It needs articles of value and interest to most, if not all, of its readers. It needs advertising—both for the advertising section and to make its circle of readers larger.

OF STUDIES

Studies serve for delight, for ornament, and for ability. Their chief use for delight is in privateness and retiring; for ornament is in discourse; and for ability is in the judgment and disposition of business. For expert men can execute, and perhaps judge of particulars, one by one; but the general counsels, and the plots and marshaling of affairs, come best from those that are learned. To spend too much time in studies is sloth; to use them too much for ornament, is affectation; to make judgment wholly by their rules, is the humor of a scholar. They perfect nature, and are perfected by experience; for natural abilities are like natural plants, that need pruning, by study; and studies themselves do give forth directions too much at large, except they be bounded in by experiencee. Crafty men contemn studies, simple men admire them, and wise men use them; for they teach not their own use; but that is a wisdom without them, and above them, won by observation. Read not to contradict and confute; nor to believe and take for granted; nor to find talk and discourse; but to weigh and consider. Some books are to be tasted, others to be swallowed, and some few to be chewed and digested; that is, some books are to be read only in parts; others to be read, but not curiously; and some few to be read wholly, and with diligence and attention. Some books also may be read by deputy, and extracts made of them by others; but that would be only in the less important arguments, and the meaner sort of books; else distilled books are like common distilled waters, flashy things. Reading maketh a full man; conference a ready man; and writing an exact man.

"Essays"—Francis Bacon.

ENGINEERING SOCIETIES

THE ARMOUR INSTITUTE OF TECHNOLOGY BRANCH OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

The Mechanical Engineering Society has changed its place of meeting from Machinery Hall to the auditorium in the Mission in order to provide seats for all of those desiring to attend.

In adherence to the plan for the conduct of our meetings two or three talks are given each time by members chosen by the President.

This system has produced a great many interesting and instructive speeches. Mr. Swenson explained the various methods that have been used for lubricating the flanges on locomotive wheels in order to reduce the friction developed between the rail and the flange.

A deeper insight into the mysteries of the "royal and ancient" game of golf was afforded those who heard Mr. Kinsman's talk on the manufacture of golf clubs.

At a later meeting Mr. Bissel explained the Dutch Boy process of manufacturing white lead. Mr. Walsh outlined the system that the telephone company is employing in the automatic telephones now being installed.

Mr. Herman read a paper in which he discussed the losses encountered in the small power plant and the economical feasibility of reducing them.

Mr. A. E. Johnson gave an interesting talk on the manufacture of rubber tires as observed by him while on the flying squad of the Goodyear Rubber Co. at Akron Ohio.

The Mechanical Engineering Society has carried on the good work of former years and its activities have exceeded the hopes of the most optimistic.

The spirit and interest displayed by the student members is very gratifying.

Keep up the good work! David S. Jennings, Sec'y.

WESTERN SOCIETY OF ENGINEERS

The W. S. E. smoker, mentioned in the last issue of The Engineer, was a decided success, thanks to the activities of the social committee, Watt, Munday and Hess. The feature of the evening was a series of impersonations by the brother of Raymond Hitchcock, gales of laughter being evoked from both students and professors. A well-known M. E. student, upon seeing part of the act and the spirit of the audience, expressed his desire to change his course His presence at the smoker evokes a suspicion as to the probable perpetrators of the kidnapping of the cider barrel. But, thereby hangs a tale. Needless to say, after two ghosts of the cider barrel had arrived and been sampled to the sampler's disgust, the real cider returned to our gathering. The *drinking* of the cider, the eats and smokes completed the enjoyment of the evening.

Since our last report, four meetings have been held. At the first of these Benjamin F. Morrison was elected to the Presidency to fill the vacancy caused by the non-return of Mr. Campbell to school.

At the second meeting, Mr. Morrell, Chairman of the Public Speaking Committee of the W. S. E., spoke on "Public Speaking for the Engineer." While public speaking is not so simple that it may be reduced to a formula, the speaker's presentation and demonstration of his subject should serve to make his hearers' ideas of the subject more definite and capable of expression. He made the statement that the need of the engineer is advertising, and that one of the best ways of obtaining the same was through engineers capable of speaking well in public.

At our last meeting we had the pleasure of listening to Mr. K. E. Kellenberger, Editor, Railway Signal Engineer, who spoke to us on the "Relation of Railroad Signaling to the Railways." His presentation of the History of Signaling, the requirements of the work, and the present-day methods of Signaling and Interlocking were interesting and instructive. The subject is one of which little is known outside of the members of the profession, while being one which vitally concerns us if we travel at all. The article in this issue of The Engineer about the same subject should be of additional interest to those who had the opportunity of hearing Mr. Kellenberger's talk.

The life of an organization, no matter what kind, is attested

through the interest shown in its affairs by the members of the organization and by those not members. That the interest shown by both in our society is increasing is evident, but there are still some members of our department who, by their apathy and indifference to departmental activities, act as a drag and a source of friction. Although the loss reverts principally to the individual, enough is felt by the society as a whole to encourage the members of the same to persuade these recalcitrants to give their support.

—E. M. Seaberg,
Secretary.

ARMOUR RADIO ASSOCIATION

The Armour Radio Association is a live and going organization, as may be seen from the rapidly increasing attendance at the meetings. The Freshmen and Sophomores have shown a much greater interest in radio this year than ever before, as a large number of the lower classmen are now members of the A. R. A.

At the second regular meeting, held in the Physics Lecture room on November 2, 1921, Mr. H. I. Hultgren gave an illustrated lecture on the method of measuring the constants of vacuum tubes. He described both the static and the dynamic methods of measuring the amplification factor and the internal impedance. The static method enables one to calculate the constants from characteristic curves which may be obtained from the manufacturers of the tubes or from laboratory tests. In the dynamic method, a Wheatstone Bridge circuit, supplied with an alternating e m. f., is used, and the constants of the tube can be measured under various conditions of plate potential, grid potential, and filament current.

The next regular meeting of the A. R. A. was held on November 16, 1921. Mr. R. S. Kenrick gave a short talk on "The Effect of Frequency on the Internal Impedance of Vacuum Tubes." He showed that the internal resistance of a vacuum tube is constant with respect to the frequency and that reactance is very nearly inversely proportional to the frequency. The internal impedance is a function of the resistance and reactance, and therefore decreases with an increase of frequency, and vice-versa. Mr. Kenrick also pointed out that the internal impedance depends on the filament current and the potentials applied to the grid and

plate, so that these factors must be included in any data on the internal impedance.

Our fourth meeting was a novel one in that one of the speakers was not a radio operator or a student in the electrical engineering department, as the speakers have been heretofore. Mr. J. Warren McCaffrey, a chemical engineering student, delivered a very interesting and timely talk on "Self-Rectification for Vacuum Tube Transmitters." Much of the material for this talk was taken from reports of the Bureau of Standards, which the average amateur radio operator decides are too deep to be read thoroughly. After describing in detail the method of self-rectification, Mr. McCaffrey pointed out its advantages and disadvantages. Self-rectification greatly lessens the first cost and the operating expenses of continuous wave transmitters, but cannot be used with radio telephony. However, a similar method may be adopted for radiophone work, with the addition of an electrolytic or a vacuum tube rectifier.

Mr. E. Herskovitz described the "Negatron," a British four-element tube, which has a negative resistance characteristic. Professor Wilcox described an older type of tube possessing similar characteristics, and also pointed out the uses to which such a tube might be put.

The receiving outfit was mounted in a temporary manner so as to be able to receive Grand Opera, which is being transmitted by radio from radio station KYW, belonging to the Westinghouse Electric and Manufacturing Company, and located on the Edison Building. By using the "Magnavox" loud speaker, it has been possible to favor several large audiences in the school with Grand Opera. During the mid-winter recess, the receiving outfit will be installed in permanent form, and very shortly after, a regenerative receiver will be purchased by the Association. This will greatly improve the reception of the Opera, as well as signals from all short wave stations.

There are a number of radio men in the school who have not as yet joined the Armour Radio Association, and it is the earnest wish of the officers of the A. R. A. and also of its present members that every radio man in the school will show his school spirit and affiliate himself with the Association.

— Edward A. Goodnow, Secretary.

THE AMERICAN INSTITUTE OF ELECTRICAL ENGINEERING

The A. I. E. E. has been very fortunate in being able to have talks by members who have had commercial experience. Several of the A. I. E. E. members are doing commercial operating and their talks prove very interesting.

The third regular meeting of the society was held on November 22, 1921, in the Electricity Lecture room. The meeting was featured by an illustrated talk on "A Trip Through a Modern Sub-Station." Mr. C. M. Kraemer, a sub-station operator of wide experience, surely gave the members a treat by his talk. He not only had an unlimited supply of slides, which he showed and commented on, but he also had a complete wiring diagram sketched on the blackboard. With this diagram he showed how the different pieces of apparatus function, and how the apparatus is used commercially. Questions asked by the members, during and after Mr. Kraemer's talk, were conclusive evidence of the interest shown.

Professor Snow made a few remarks on the joint meeting of the A. I. E. E. and W. S. E., which was held on November 23, 1921, in the W. S. E. rooms in the Monadnock building. Several members attended the meeting, and from their reports it proved very interesting.

The Smoker held on December 2, 1921, was a complete success. Chairman Burns opened the meeting with a few remarks and then called on Professor Snow and Professor Lesser, who in their turn made several remarks and good suggestions. The Chairman then introduced the speaker of the evening, Mr. E. S. Hurd, of the American Welding Society. This society came forth from the Emergency Fleet Corporation, which was organized during the war.

Mr. Hurd gave an exceptionally interesting talk on "Electric Arc Welding." He discussed in detail the various methods used. During his talk he distributed for examination numerous samples of work done by means of electric arc welding. He pointed out facts that were discovered during the war period that completely revolutionized electric welding.

After Mr. Hurd's talk, the "eats" were brought forth. "Smokes" were plentiful, while the "doughnuts and—" were enjoyed by all.

To "cap" off the evening a two-reel motion picture comedy

was shown. This picture was obtained through the efforts of Mr. Burns, and was surely enjoyed.

The meetings in the past have enjoyed a good attendance, and we sincerely hope to keep it up.

Lester E. Grube, Secretary.

THE ARMOUR CHEMICAL ENGINEERING SOCIETY

The last regular meeting of this society was held November 30 on the fourth floor of the Institute. The feature of the meeting was an extraordinarily interesting talk given by Prof. J. J. Schommer on the general subject: "Adulteration." His talk was good up through the last word. It was an effort on Professor Schommer's part to impress the members of the society with the countless number of ways in which products of chemical industries are in danger of substitution. He lent a considerable part of the hour to a discussion of the substitutes and adulterants of food products. His closing remarks embodied considerable sound professional advice through which many of the members came to a better appreciation of business ethics. At the close of his talk those present gave repeated expression of their appreciation.

During the first semester of this school year the senior members of the society have profited by reason of inspection visits to certain of the best plants of the chemical industries in and around Chicago. Among the places visited were:

National Lead Co., Chicago.
Carter White Lead Co., West Pullman.
Heath & Milligan Paint Co., Chicago.
Armour & Co. Rendering Plant, Chicago.
Holman Brothers Soap Co., Chicago.
Pope Sugar Beet Factory, Riverdale.

The entire society was accompanied by the senior electrical students on an inspection visit to Goldsmith Brothers Smelting & Refining Co. It was unfortunate that the visit was made during a lull in business, on which occasions the company engages in reconstruction work. The objects of mutual interest to both the chemical and electrical students were the electrical precipitation of flue dusts, and a high frequency electrical induction furnace that could attain a maximum heat in about fifty seconds.

J. Warren McCaffrey, President.

COLLEGE NOTES

WENDELL M. BAKER

Wendell M. Baker, son of Mr. and Mrs. Harry T. Baker, died at his home in Beverley Hills on December 17, 1921, after an illness of about one month. Interment was at Mount Hope Cemetery on December 19. The senior chemical students turned out in a body along with many other of his classmates and friends from the school to attend his funeral. Several of his close friends from college served as pallbearers and flower-bearers.

Wendell Baker was born May 23, 1901, and was a graduate of the Morgan Park High School. He entered Armour Institute of Technology in the fall of 1918 as a freshman, enrolling as a student of chemical engineering. His bright intellect, pursuit of knowledge and jovial disposition soon put him out in the front of his class, and at the time of his passing away he was a member of the senior class with an enviable scholastic record.

His efforts in behalf of the Y. M. C. A. were rewarded by the members of that body electing him president for a full term. His ever-ready jokes, wit and humor made him the logical choice for editor of the humor section of the 1920 Cycle. While thus becoming popular he was in nowise losing sight of his primary object at the Institute—to assimilate his studies in a scholarly fashion. His success in that direction is attested to by his election as a Junior to the honorary chemical fraternity, Phi Lambda Upsilon, and as a Senior to the honorary engineering (general) fraternity, Tau Beta Pi.

In the passing of a student of such a high caliber as Wendell Baker we are brought face to face with the vicissitudes of life. He gave great promise of being a decided asset to his chosen profession. His wit and humor and characteristic "funny" stories had won for him many friends. And little doubt was there that time and deeds would transplant him from the front ranks of his class to the vanguard of chemical engineers. However, he has been called from this life and he is lost to both those he left behind and his chosen profession, while we, bereft of his friendship and companionship, must "carry on" without our beloved classmate. J. Warren McCaffrey.

ROY M. FARWELL
FREDERICK W. HILLIKER

It seems strange that at the same time as we record the death of one who would at the end of this year have completed his course at Armour, we find it necessary to record the passing of two men who were students at the Institute last year but did not return this term.

Roy Farwell succumbed on December 19 after an illness of almost a year and was buried December 21 from his home in Oak Park, Ill. He entered the Mechanical Engineering Department of Armour in the fall of 1919, but was forced to leave school on account of his health in the early part of 1921. He was a member of Sigma Kappa Delta Fraternity. During that part of the second year he was able to spend in school he held the presidency of the Freshman-Sophomore branch of the American Society of Mechanical Engineers, Armour Branch.

Frederick W. Hilliker was so seriously injured when an automobile he was driving was struck by an interurban car, that he died at St. Luke's Hospital, Chicago, soon after. The accident occurred on the afternoon of November 19 near the city limits southeast of Chicago. He had attended Armour for three years, but instead of returning for this term, had taken up the study of methods of steel manufacture and sales, and up to the time of his death was located at Indiana Harbor. His home was in Morris, Ill. He was a member of Delta Tau Delta Fraternity.

ASSEMBLIES

It was our pleasure, at our first assembly in the last month, to listen to Mr. Taylor talk on the Chicago Plan. The talk was illustrated by, in fact centered around, numerous slides. To most of us, the Chicago Plan had been more or less of a hazy idea, but it is sure that this talk made the whole thing take more definite shape as far as our minds were concerned. It is something in which we as engineers should take a great interest for the practical application of the Plan will require the work of engineers with vision and imagination. We are all interested in seeing Chicago take first place among cities, as far as beauty is concerned, knowing that as it improves in this direction, it is bound to assume leadership in fields where it cannot now lay claim to being the first and foremost.

We heard that twelve of the most important projects under the Chicago Plan are already under way or are assured of a beginning in the near future. Of these might be mentioned the South Water Street improvement, the Michigan Avenue Bridge (and, by the way, $100,000 has been donated toward beautifying the towers of this bridge), the Roosevelt Road project, the filling in of the lake front and the making of a park along the lake shore from Jackson Park to the far North Side, the widening of Western Avenue, and the creation of Pershing Road,—not to mention various others.

Our second Assembly took the form of a pep meeting, of almost startling character in spots, and to all appearances marking the beginning of a new epoch in the activities of the school.

Dean Raymond opened the meeting with a few remarks as to its purpose and then introduced Prof. Amsbary, who regaled us with a few of his ever-appreciated selections. His word painting of a dish of strawberries probably caused the partial solvency of every palate in the audience.

Prof. Schommer then further delineated the purpose of the meeting, with a few of his wonted high-explosive remarks. The object of the assembly was to present the idea of an Athletic Association to the student body. The thought of having an Armour Athletic Association was conceived by the Junior Class, and brought to its present state of development through a committee appointed by them with Mr. H. W. Munday as chairman. Summed up in three words by Mr. Munday, the purpose of the A. A. A. will be, "TO BOOST ARMOUR."

The work of the Association will be to stimulate support of athletics and to take care of schedules, entertainment of visiting teams, and needs of our own team; to obtain additional songs and yells and to see that the student body is trained to use them to best effect; to foster class and fraternity athletics.

Secondly, it is to aid in the support of the college publications in every way possible.

Thirdly, it is to co-ordinate the work of the various engineering societies. The financial support of the organization is to be obtained from a fee payable with the tuition. And, all classes are to be represented in the Association.

Prof. Schommer introduced as speakers, Messrs. Munday, Schumacher, McCaffrey, Rutishauser and Edwards, and Profs.

Paul and Freud and Coach Krafft. Each emphasized the need of an organization of this kind. Profs. Paul and Freud assured some doubters that the faculty was behind the movement and that after all, they really favored anything benefitting the school and the students.

The selections rendered by the Musical Clubs were excellent and appreciated as such.

* * *

Prof. D. F. Campbell represented the Institute at the installation ceremonies of President Moore of Lake Forest University on Nov. 4, 1921.

Acting President Howard M. Raymond was the representative of the Institute at the installation and inauguration ceremonies of President David Kinley of the University of Illinois at Urbana on Dec. 1st and 2nd, 1921.

At the annual meeting of the American Association for the Advancement of Science held in Toronto, Canada, Dec. 27-31, the delegate of the Institute was Prof. G. M. Wilcox.

* * *

The annual Senior and Junior dances were held in the French room of the Drake Hotel on the nights of November 11th and December 9th, respectively. Both were remarkable successes, even for Armour dances, although the floor on both occasions was somewhat crowded. Mr. F. G. Hochriem, social chairman of the Senior Class, and the other members of the social committee deserve special mention because their untiring efforts enabled the dance to be such a financial success as to make possible the payment of the debt incurred by the class last year in publishing the Cycle.

Both occasions were honored by the presence of Dean Raymond and his wife and daughter.

The annual Sophomore dance is to be held in the Red room of the Hotel La Salle on February 17th.

BEG PARDON

Prof. R. J. Foster, mentioned in the November ENGINEER as being an instructor in Actuarial Science, is an instructor in the Department of Mechanical Engineering.

THE FIRST ANNUAL FROSH FROLIC

"For there is nothing either good or bad, but thinking makes it so."—Shakespeare.

On the night of December 7th a crowd such as was never seen in the Armour Mission outside of Commencement Week, gathered for the purpose of being entertained by such members of the Freshman class as had enough courage and ability to face the audience with that idea in mind. The crowd consisted of a number of Armour men, primarily, with their companions, or friends, or friends plus, or sweethearts, or fiancés, or perhaps their parents. So you see it was quite a family affair. Yes, Dean Raymond, Professor Penn and some others were also there.

The sponsors of the "Frolic" were the members of the Junior class, with Mr. C. W. Hauth as the accredited originator of the idea. With Mr. C. C. Kruse, Mr. Hauth managed the entertainment. The belief that there should be some school activity besides Circus Day to which the student might bring his friends and parents and show them the environs in which he was receiving his education, prompted the idea. With the assurance of the Dean's office of their support it was carried out and with such success that it promises to become a custom, as Junior Week now is.

The program consisted of selections by the Glee Club, musical and vaudeville numbers, some examples of the wonderful feats made possible by the "mystic art of legerdemain," and a jigging contest. Music was furnished at intervals by the Freshman Orchestra.

While the desire to go on the stage will probably never interfere with the engineering careers of the participants in the "Frolic," it seemed that we can safely say, "A good time was had by all."

FRATERNAL NOTES

The Tau Beta Pi fall initiation was held on December 3rd and the banquet was held in Stillson's restaurant on the evening of December 7th. The initiates were those whose names were mentioned in the last issue of The Engineer as pledges, with the exception of W. M. Baker, The aptitude of some of the pledges for general repair work was given an opportunity for trial on various doors and fixtures of the Columbia College of Expression,

and conditions there are reported to be better in consequence.

The Eta Kappa Nu initiation was held the following Saturday, December 10th, and the initiates are reported to be sadder but wiser men.

The initiation into Phi Lambda Upsilon was held on December 17th.

An inter-honorary-fraternity smoker, sponsored by Tau Beta Pi, was held on the evening of December 20th. Most of the members of the four honoraries, including the Scarab, were out on the occasion. The program consisted of a selection of readings by Professor Amsbary, and short talks by Mr. G. V. Bradbury and E. M. Seaberg, in addition to the usual smokes. An inter-honorary dance is to be held on Friday, Feb. 10, in the Lincoln Park Refectory.

* * *

Registration, First Semester, 1921-22.

Course	Sen.	Jun.	Soph.	Fresh.	Special	P. G.	Total
M. E.	29	48	48	48	4	..	177
E. E.	22	34	46	70	2	..	174
C. E.	20	39	33	28	..	..	120
Ch. E.	18	18	31	37	1	..	105
F. P. E.	3	7	25	27	..	..	62
Arch.	12	13	14	21	11	1	72
Ind. Arts.	.	..	..	4	..	..	4
Total	104	159	197	235	18	1	714
Year 1920-21							
Total	95	127	217	250	25	..	714

WEATHER FORECASTS

Twice-daily weather forecasts are made by the district forecasters at Washington, Chicago, Denver, New Orleans, and San Francisco for each State in the groups of States surrounding their stations. The morning forecasts are made at about 9 a. m. (eastern time), and cover the probable conditions for the next 36 hours. These forecasts are promptly telegraphed to about 1,600 distributing points, whence they are further disseminated by telegraph, telephone, wireless, and mail. They reach nearly 100,000 addresses by mail, and are available to more than 5,500,000 telephone subscribers within one hour after the time of issue.

Yearbook, 1920, U. S. Dept. of Agriculture.

BASKET BALL

With half of the basketball schedule over, we can take time out to look back and see what kind of a record has been made.

The first game was with the American College of Physical Education, on November 29, at Armour. The game was fast and rough but we came out the victors by a score of 38 to 34. The initial lineup was: Norton, Witashkis, Schumacher, forwards; Rutishauser, center; May, McLaren, Johnson, guards.

On December 3, the team went to Evanston and played Northwestern University. The basketball court in Patten Gym is considered one of the hardest for a new team and so, after holding them to a 10 to 6 score in the first half, we were beaten, 27 to 10.

Both Crane Junior College games were won. The first score was 28 to 25; the second 29 to 21.

The game with Chicago University was hard fought but resulted in defeat for Armour, 27 to 14.

The Notre Dame game was played on a neutral floor at the Y. M. C. A. College. A good crowd saw the game. The first half ended 22 to 5 against us, but the team came back strong the second half and made the final score 33 to 17. In this game Witashkis had his eye badly hurt.

When the Armour Post of the American Legion was played, only four regulars were in condition, as injuries kept out several players. The score was 40-16.

The team reported for practice the last week of Christmas vacation and several new men were added to the squad.

The Alumni presented a strong lineup. Their team included: Mouat, Bready, Ahlbeck, Broman, Havlick, Trinkhaus, Sandorf and Neufeldt. The varsity lineup was: McLaren, Witashkis, Schumacher, forwards; Spaid, center; Rutishauser, May and Johnson, guards. The first half ended 13 to 9 in favor of the varsity but Mouat opened an attack that gave the alumni a two-point lead which the varsity was unable to overcome. The final score was 26 to 24.

Despite the fact that it was Friday, the 13th, the team left for Kalamazoo to play the Western State Normal. The nine men taken were: Rutishauser, Schumacher, McLaren, Witashkis, Spaid, Johnson, May, Farrell and Plocar. The game in the evening was very fast and although the floor work of the Armour team was as clever as their opponents, the Normal players

proved to be the best shots. The score was 31 to 17. The Normal team displayed a fine brand of sportsmanship and we hope to have a game with them in baseball.

The following day the team left at noon for Detroit to play the University of Detroit. This game was the hardest fought game that has been played. The Detroit team penetrated our defense quite often the first half and as a result the score stood 10 to 5 against us. The second half started with a rush and gradually, point by point, we gained on them. The Armour defense had strengthened so much that the Detroit team seldom had a chance to shoot. The score was tied for about five minutes at 15 all, but with only a few minutes to play Schumacher sunk a long basket and Spaid followed with a short one. Schumacher made another basket and a free throw, making the final score 22 to 15.

There is a possibility that a game will be arranged with the Milwaukee School of Engineering and Ohio State University.

HINTS ON READING

If we encounter a man of rare intellect, we should ask him what books he reads. —Emerson.

For Clearness read Macaulay.
For Logic read Burke and Bacon.
For Action read Homer and Scott.
For Conciseness read Bacon and Pope.
For Sublimity of Conception read Milton.
For Vivacity read Stephenson and Kipling.
For Imagination read Shakespeare and Job.
For Elegance read Virgil, Milton and Arnold.
For Common Sense read Benjamin Franklin.
For Simplicity read Burns, Whittier and Bunyan.
For Humor read Cervantes, Chaucer and Mark Twain.

—Library Journal.

THE ALUMNUS

Being That Part of **The Armour Engineer** Devoted to Personal Mention of the Graduates of the Armour Institute of Technology and to the Affairs of the Armour Alumni Association.
Communications should be addressed to
W. J. Bentley, Armour Institute of Technology, Chicago, Ill.

Officers of the Armour Alumni Association for 1921-22.

W. A. Kellner '10..................President
Ray J. Koch '13...............Vice-President
Harold S. White '17.................Treasurer
Walter H. Hallstein '14....Recording Secretary
Walter J. Bentley '20..Corresponding Secretary
Morris W. Lee '99......Master of Ceremonies

Board of Managers.

Retiring 1922	Retiring 1923	Retiring 1924
R. M. Henderson '02	C. A. Knuepfer '15	W. D. Matthews '99
J. C. Penn '05	F. C. Dierking '12	Wm. H. Long '02
B. S. Carr '15	Sidney V. James '07	M. A. Smith '10

ALUMNI NOTES

The Officers and Board of Managers have held frequent meetings and a comprehensive outline of new activities has been developed. This will be submitted to the general winter meeting of the Association for approval and we hope to see in its fruition a more vigorous and active Alumni Association.

The luncheons, held on the first and third Fridays of every month at 12:15 P. M. at the Hamilton Club have proven a great success. The attendance has varied from 30 to 80 and appears to take its support not from a few faithfuls, but from the periodic attendance of the many. We feel satisfied, therefore, that the luncheons are promoting good fellowship and a wider acquaintanceship among the Alumni.

However, this is a local activity which to be of general benefit must be applied at many centers, each of which would then constitute a chapter of the Alumni. Such a system of chapters—large or small—would provide the channel through which Armour men could come in contact. Certainly their activities would greatly benefit both the Association and the individual members. The only chapter, outside of Chicago, now established is the

one at Pittsburg. This has provided many social affairs for the members and their families and has proven a real success. H. S. Ellington, '08, has undertaken to start a branch at Detroit and we know he will make a success of it. We are anxious to hear from volunteers and will gladly give them all the assistance possible.

Mention the Alumni activities to all Armour men whom you meet and give them the opportunity to enjoy the benefits of the Association. Then, too, when you hear an interesting bit of news of a classmate don't forget to pass it on so that we can make the "Engineer" a real Alumni Bulletin. Most of the personals in this issue have been gleaned from the reply form on the bills for dues, and so present very few details. Let us all help by sending in our quota for the next issue. Last and most important of all, let us know all your criticisms and suggestions.

W. J. Bentley,
Corresponding Secretary.

PERSONALS AND NEW ADDRESSES

'97

Loney, N. M., 124-15 Cranston Ave., Rockaway Beach, N. Y.; Vice President Thompson-Starrett Co., 51 Wall St., New York, N. Y.

Perry, Robt. V., 6340 Normal Blvd. Chicago, Ill.

Sloan, J. R., 132 So. Grand View Ave.,, Crafton Boro, Pa.

Sims, W. F., Field Engineer, Inside Plant Division, Commonwealth Edison Co., is very busy at the present time on the construction of the new Calumet station. We hope to hear more from Mr. Sims when the station is completed.

Singer, Sidney Charles, 311 N. Reno St., Los Angeles, Cal.

'98

MacKenzie, Donald, Engineer with Swift & Co., is now located at the U. S. Yards, Chicago, Ill.

'99

Goodhue A. H., Bus. Add., 1315 E. 52nd St., Chicago, Ill.

Marienthal, Oscar B., Supt. W. W. Alschlager & Co., 65 E. Huron St., Chicago, Ill.

'00

Harvey, Dean, 109 Dewey Ave., Edgewood, Pittsburg, Pa.

'01

Bernhard, F. H., Electrical Trades Publishing Co., Room 824, 53 W. Jackson Blvd., Chicago.

Cohen, Louis, Consulting Engineer Signal Corps, U. S. A., has been appointed Technical Adviser to the Disarmament Conference now in session at Washington, D. C.

Pierce, Charles W., Electrical Contractor, 4228 Calumet Ave., Chicago.

'02

Eyer, B. F., General Manager Fortified Mfg. Co., 1401 Agnes Ave., Kansas City, Mo.

Harris, R. H., 6238 St. Lawrence Ave., Chicago, Ill.

Henderson, R. M., Grosvenor St. and Center Drive, Douglas Manor, L. I.; Vice President Dwight P. Robinson Co., 125 E. 46th St., New York, N. Y.

Lang, Wm. H., 4318 Evans Ave., Chicago, Ill.

Larkin, F. G., 5262 18th Ave., N. E., Seattle, Wash.

Reiniger, R. G., Secretary-Treasurer Globe Elect Co., 313 Occidental Ave., Seattle, Wash.

Sanford, L. A., American Coke & Chemical Co., Room 1133, 208 S. LaSalle St., Chicago.

'03

Niestadt, Geo. W., 1430 Thorndale Ave., Chicago, Ill.

Strickler, John F., Evanston, Ill., Engr. Bray Pictures Cor. 208 S. LaSalle St., Chicago, Ill.

Taussig, W. S., is leaving shortly for an indeterminate stay in China.

'04

Abell, H. C., Vice President Electric Bond & Share Co., 71 Broadway, New York, N. Y.

Hammond, Chas. H., 64 E. Van Buren St., Chicago, Ill.

Heinen, Emil J., 4528 Nokomis Ave., Minneapolis, Minn.

Lundgren, Leonard, Capt. Eng. Corps, care American Society Engineers, New York, N. Y.

Prescott, Orson R., 929 N. Waller Ave., Chicago, Ill.

Williams, Roy E., 6224 Prairie Ave., Chicago, Ill.

'05

Carroll, E. J., 6303 Lakewood Ave., Chicago, Ill.

Felgar, J. S., 743 DeBarr Ave., Norman, Okla.

Hein, P. L., Room 538, State-Lake Bldg., Chicago, Ill.

Hay, W. G., Redford, Mich.

'06

Allen, O. F., 109 Wisconsin Ave., Oak Park, Ill.

Byanskas, John, 840 W. 33rd Place, Chicago, Ill., Western Electric Co., Hawthorne, Ill.

Hiller, E. F., 5321 Woodlawn Ave., Chicago, Ill.

Keith, Grover, 7117 Yale Ave., Chicago, Ill., Engr. U. S. Gypsum Company, 205 W. Monroe St., Chicago Ill.

Klapper, Chas., 2517 S. Keeler Ave., Chicago, Ill., Consulting Structural Engineer.

Klein, Samuel, 225 E. Erie St., Chicago.

Moreton, D. P., 7235 Vernon Ave., Chicago.

Wilson, Wm. Robt., Pres. Maxwell-Chalmers Motor Corporation.

'07

Blumenthal, Ed. A., Pres. Gabriel Snubber Co., 1337 Michigan Ave., Chicago, Ill.

Boehmer, A. H., 5552 Van Buren St., Chicago, Ill.

Eustice, A. L., 1138 Sheridan Road, Evanston, Ill., Pres. Economy Fuse & Mfg. Co., 2800 N. Greenwood Ave., Chicago, Ill.

Mathews, John F., 6230 S. Park Ave., Chicago, Ill.

Wells, John B., 1124 W. Commonwealth Ave., Alhambra, Calif., Field Eng. Lucey Mfg. Corp., 1515 E. 7th St., Los Angeles, Calif.

'08

Jacobson, Jos. H., Elect. Contractor, 58 W. Washington St., Chicago, Illinois.

Packer, C. S., Bond Salesman, Dillon, Read & Co., 209 S. LaSalle St., Chicago, Ill.

Schram, I. H., 111 Genesee St., Hornell, N. Y., Eng., Erie R. R., Hornell, N. Y.

'09

Boblett, K. M., 626 Nesslewood Ave., Toledo, Ohio.

Buckett, Arthur C., 1150 Linden Ave., Wilmette, Ill., Architect, 155 N. Clark St., Chicago, Ill.

Hall, A. G., Douglaston, N. Y.

Hammond, E. K., formerly located in New York City as Associate Editor of "Machinery," has been appointed Western Editor with offices at 29 S. LaSalle St., Chicago, Ill.

McMullen, E. W., is now Chemical Engineer and Director of Industrial Welfare of the Simmons Mfg. Co., Kenosha, Wis.

Obenfelder, Walter, Albert Dallemand & Co., 110 S. Dearborn St., Chicago, Ill.

Spitzglass, J. M., 751 Junior Terrace, Chicago, Ill.

Stadiker, G. I., 1106 E. 53rd St., Chicago, Ill.

Valerio, J. M., owner K. & K. Electric Shop, 3530 W. North Ave., Chicago, Ill.

'10

Barrows, Frank E., 67 Brookfield Road, Upper Montclair, N. J., member of firm Pennie, Davis, Marion & Edwards, 165 Broadway, New York, N. Y.

Baer, Walter J., 250 Riverside Drive, New York, N. Y.

Carlson, Harry W., 552 N. Central Ave., Chicago, Ill., Appraisal Engineer, No. 2566 Treasury Annex, No. 2, U. S. Treasury, Washington, D. C.

Hatman, J. G., 3307 N. 17th St., Philadelphia, Pa.

Kellner, W. A., Office Engineer, C., M. & St. P. R. R., Powers Bldg., Monroe and Wabash Ave., Chicago, Ill.

Leavell, R. A., is organizing training for U. S. Veterans, Bureau Vocational School, No. 1, Camp Sherman, Chillicothe, Ohio.

Mac Ewing, E. D., 3005 Eastwood Ave., Chicago, Ill.

Richards, Olin Lewis, Dodge Bros., 1330 La Salle Bldg., St. Louis, Mo.

Squair, F. R., 414 W. 22nd St., Wilmington, Del.

'11

Alling, H. M., Apt. 511, Hotel Astor, Milwaukee, Wis. Engr. Chris Schroeder & Son Co., 86 Michigan St., Milwaukee, Wis.

Hay, Robt., Prop. Auto Elec. Service Garage, Rock Springs, Wyo.

Hills, Geo. B., announces the establishment of Geo. B. Hills Co. Successor in the south to Isham Randolph & Co., Civil Eng. Barrett Bldg., Jacksonville, Fla.

Lohse, A. C., Master Mechanic, J. H. Williams Co., 1000 W. 120th St., Chicago.

McGuire, Wm. P., 105 Euclid Ave., Indianapolis, Ind. Engr. Indiana Inspection Bureau, 1305 Merchants Bank Bldg., Indianapolis, Ind.

Sieck, Herbert, Sieck & Druecker Inc., 332 S. Michigan Ave., Chicago, Ill.

Smith, S. M., is at present Resident Engineer on the construction of a Bascule bridge of new design for the Wabash Railway across the Rouge River in Detroit, Mich.

Tellin, Wm. G., 38 S. Dearborn St., Chicago, Ill

'12

Anderson, S. C., 2830 Virginia Ave., Louisville, Ky. Asst. Supt., Riverside Refinery, Standard Oil Co., 426 W. Bloom St., Louisville, Ky.

Beach, Wm. E., Consulting Engineer, V. D. Simons Co., 601 N. Y. Life Bldg., Chicago, Ill.

Dierking, F. C., 3540 W. Jackson Blvd., Chicago, Ill.

Drew, H. A., Downers Grove, Ill. Sales Eng., Edison Storage Battery Co., 3130 S. Michigan, Ave.,, Chicago, Ill.

Koller, Louis H., 6642 Van Buren St., Oak Park, Ill.

Oehne, W. S., 5635 Prairie Ave., Chicago, Ill.

Ross, Ralph R., 2601 Cass St., Omaha, Neb.

Strale, Nels W., 434 E. 46th Place, Chicago, Ill.

'13

Arenberg, A. L., Mgr. of Lighting Division Central Elec. Co., 316 S. Wells St., Chicago, Ill.

Bradford, J. D., Engr., The Koppers Co., Union Arcade Bldg., Pittsburgh, Pa.

Cooper, Howard, Lubrication Eng., The Texas Co., 1350 McCormick Bldg., Chicago, Ill.

Marx, Walter L., 957 Webster Ave., Chicago. W. A. Zelnicker Railroad Supply Co., St. Louis, Mo.

Oper, O. L., Riverside, Ill. Asst. Eng., Maur, Green & Co., 400 N. Michigan Ave., Chicago, Ill.

Rothwell, Richard F., 2055 Fairfax Rd., Columbus, Ohio. Supervisor of Production, R. L. Dallings Co., Columbus, Ohio.

Stump, Don M., 5451 W. Monroe St., Chicago, Ill.

Trujillo, Felix A., 22 W. Goethe St., Chicago, Ill.

Walin, Herbert S., Hazelton & Walin, Ltd., 609 Electric Ry. Chambers, Winnipeg, Manitoba, Can.

'14

Fleming, M. J., 1002 Ottawa Ave., Ottawa, Ill.

Himelblau, Harry, 7463 N. Seeley Ave., Chicago, Ill.

Hoffman, E. L., 5536 So. Park Ave., Chicago, Ill. Elec. Contractor, 4859 Cottage Grove Ave., Chicago, Ill.

Koch, Abert N., 821 Collingwood Ave., Detroit, Mich.

Koenigsberg, Nathan, Architect, 5 N. La Salle St., Chicago, Ill.
Menke, E. W., 11318 Yale Ave., Hammond, Ind.
Shakman, J. G., International Filter Co., 38 S. Dearborn St., Chicago.
Walker, S. P., 3803 Belleplaine Ave., Chicago, Ill.

'15

Carr, B. S., formerly Mechanical Sales Engr. for the American Manganese Steel Co., Chicago Heights, Ill., has been appointed manager of the Pump Department, and is busily engaged in the development of dredge pumping.
Deering, J. J., Elec. Eng., Bureau of Public Works, Manila, P. I.
Deitenback, Max, 19 Elm Ave., Chicago, Ill.
Griffith, A. B., Architect, 820 S. 59th St., Omaha, Neb.
Grodsky, Morris, Instructor at Lewis Institute, Chicago, Ill.
Hirose, Y., Struc. Engr., Lescher, Kibbey & Mahoney, 400 National Bank Bldg., Chicago, Ill.
Rissman, Maurice B., 139 N. Clark St., Chicago, Ill.
Sproesser, P. W., 408 S. Minnesota Ave., Sioux Falls, S. Dak.
Trinkaus, J. J., Asst. Eng., Sanitary Dist. of Chicago, 228 Canal St., Blue Island, Ill.

'16

Alter, A. S., Western Repr., Jacques Kriesbr & Co., 1103 Heyworth Bldg., Chicago, Ill.
Luckow, Wm. C., 6028 Vernon Ave., Chicago, Ill.
Marx, Victor E., 4631 N. Broad St., Philadelphia, Pa.
Wright, Chet., has deserted the band of valiant bachelors.

'17

Armspach, O. W., Bureau of Mines, Pittsburgh, Pa.
Bolte, Chas. L., Capt. of Infantry, Ft. Sam Houston, Texas.
Fitzner, A. J., 158 W. 14th St., Chicago Heights, Ill. Member of firm John Mackler & Co., 2200 Chicago Rd., Chicago Heights, Ill.
King, L. A., 7005 Vernon Ave., Chicago. Superintendent VanDorn Coupler Co., 2825 S. Paulina St., Chicago, Ill.
Mease, Arch. J., Supt., Newport Chem. Co., Passaic, N. J.
Plocinsky, A. J., 5006 N. Troy St., Chicago, Ill.
Robechek, B., Mgr. "Louis Deutch Co.," 21 N. Dearborn St., Chicago.
Rosenberg, L. H., Publicity Engineer for the Westinghouse Elec. & Mfg. Co., Pittsburgh, Pa., has been in Chicago recently supervising the operation of the "Opera Radio" transmitting station (KYW) located in the Edison Bldg., 72 W. Adams St., Chicago.
Starkel, L. E., 925 Oakwood Ave., Wilmette, Ill., with A. C. Magnuson Co., 5507 Michigan Ave., Chicago, Ill.
Watt, Wm. T., 5840 W. Circle Ave., Norwood Pk., Chicago, Ill.

'18

Cable, Donald E., 412 S. 11th St., Laramie, Wyo.
Ferguson, A. H., Tuscarawas County, New Philadelphia, Ohio.
Hullinger, Ora M., 6528 Kimbark Ave., Chicago, Ill.
Marx, F. E., Eng. Hartford Fire Ins. Co., 1422 Pierce Bldg., St. Louis, Mo.
Newlander, Ralph A., 3323 N. Monticello Ave., Chicago, Ill.

Taylor, K. A., 619 Gary Place, Chicago, Ill.

Weiss, L., 4555 Drake Ave., Chicago, Ill.

'19

Davies, L. E., 504 E. 74th St., Chicago. Lynn married last June.

Erickson, A. E., 2916 Wilson Ave., Chicago. Vice-Pres., A. A. Wickland & Co.,, Inc., Engrs., 105 W. Monroe St., Chicago, Ill.

Joslyn, E. O., is now teaching the fundamentals of Elec. Eng. at Iowa State College, Ames, Iowa.

Monks, R. E., Asst. Works Eng., Amer. Steel & Wire Co., Waukegan, Ill.

Mendius, W., 1639 E. 68th St., Chicago, Ill.

McClung, Chemist, C. R. I. & P. Ry.

Veremis, M. C., 6801 S. Halsted St., Chicago, Ill. Mr. Veremis called at the Institute the other day. He had just returned from Alaska and was considering a position in Ecuador, S. A.

'20

Cardwell, L. K., Designer, care D. R. Beeson, Architect, Johnson City, Tenn.

Gottlieb, Marshall D., 5406 Wayne Ave., Chicago, Ill. Single Sleeve Motors, Inc., 3142 S. Michigan Ave., Chicago, Ill.

Holmes, C. F., Jacobs & Halms Co., Printers and Engravers, 725 S. La Salle St., Chicago, Ill.

Marvin, Norton L., Sales Engr., Calumet Tank & Mfg. Co., 970 Old Colony Bldg., Chicago, Ill.

Muelerman, Jos. P., Test Dept., C. R. I. & P. Ry., 47th and Wentworth Ave., Chicago, Ill.

Stone, John M., VanDorn Coupler Co., 2325 S. Paulina St., Chicago, Ill.

''21

Ahlbeck, H. W., Chemist, Commonwealth Edison Co., Chicago, Ill.

Barce, S. H., Flex. Automatic Transmission Co., Chicago, Ill.

Burness, Phillip E., Instructor in Drawing, Lindbloom High School, Chicago, Ill.

Chase, D. S., 3251 Michigan Ave., Chicago. Bond Salesman, S. W. Strauss & Co., 6 N. Clark St., Chicago, Ill.

Doolittle, Chas. D., Ill. Bell Tel. Co., Evanston, Ill.

Gross, Morton, Greenwood Court, Utica, N. Y. Asst. Mgr., A. R. Swartz Co., 47 Court So., Binghamton, N. Y.

Havlick, S. N., Eng., Suburban Plant, Ill. Bell Tel. Co., 212 W. Washington St., Chicago, Ill.

Heitner, Wm. A., Underwriters Laboratories, 207 E. Ohio St., Chicago.

Haplon, Hilton, Asst. Chem., Sanitary District Lab., care Carr Prod. Ref'g. Co., Argo. Ill.

Malwitz, R. C., P. O. Box 63, Eau Claire, Wis. Has been recently appointed Construction Superintendent for the Wisconsin-Minnesota Power Co., at Eau Claire, Wis. Ray visited the Institute recently while investigating telephone transmission line possibilities.

Mann, H. A., Surveyor, Chicago Title & Trust Co., 69 W. Washington St., Chicago, Ill.

Naiman, J. M., 2726 Potomac Ave., Chicago. Consulting Engr., Hyperbo Elec. Flow Meter Co., 820 S. Tripp Ave., Chicago, Ill.

Pawloski, W. S., Priv. U. S. Army. Sec. C., A. S. M. S. Detachment, Chanute Field, Rantoul, Ill.

Pearce, W. W., is now at the Waukegan station of the Public Service Co. We strongly urge all Armour men living in the North Shore territory to send their complaints direct to the Waukegan station for personal attention.

Pfafflin, E. W., 775 Rankin St., Appleton, Wis. Chem. Eng. The Little Press Co., Appleton, Wis.

Quinlan, F. D., Cadet Eng., Peoples Gas Light Co., 122 S. Michigan Ave., Chicago, Ill.

Sanger, John P., U. S. Gypsum Co., 205 W. Monroe St., Chicago. Ill.

Schiffman, Herman M., 5234 Prairie Ave., Chicago, Ill .

Schlassman, N. J., Draftsman, Levy & Klein, 1660 Conway Bldg., Chicago, Ill.

Schreiber, Herbert F., Box 303, R. R. No. 1, Elmhurst, Ill.

Sippel, Cornelius, Jr., Attending M. I. T., 856 Beacon St., Boston, Mass.

Steiner, A. J., Asst. Engr., Underwriters Laboratories, 207 E. Ohio St., Chicago, Ill.

Van Valzah, R. W., Experimental Engineer, Morgan, Beck Co., Clearing, Ill.

Webster, S. H., 3251 Michigan Ave., Chicago. Foreman, VanDorn Coupler Co., 2325 S. Paulina St., Chicago, Ill.

Winiiarski, M. F., Western Elec. Co., Hawthorne, Ill.

Winter, E. F., 4105 Fifth Ave., Chicago, Ill. Chem., W. F. Hall Printing Co., 466 W. Superior St., Chicago, Ill.

Wolgemuth, B. C., 5409 S. Honore St., Chicago, Ill. Western Elect. Co., Hawthorne, Ill.

OBITUARY

Mrs. E. S. Libby, wife of Prof. E .S. Libby, '02.

Mrs. R. W. Kimball, wife of Raymond Kimball, '06.

Alva L. Carr, '06. Died Dec. 15, 1921.

LOCATION UNKNOWN

The Alumni Association would greatly appreciate information concerning the following men:

Anderson, A. G. 1910
Ash, Howard Joseph 1905
Baker, Earl Head 1901
Beamer, Burton Evans 1905
Bloomberg, Sheldon 1920
Botts, Thos. Edison 1917
Bowman, D. W. 1910
Charles, Walter Thomas 1902
Collins, Frank C. 1908
Collins, Frederick L. 1904
Cooney, James G. 1916
Corman, Abraham ... 1917
Cornwell, Augustus B. 1908
Coy, Frank Albert 1904
Crocker, A. H. Jr. 1910
Curtis, Harry S. 1909
Doering, Robert Carl 1911
Dumke, William 1914
Dunmore, Glenn B. 1907
Ecklund, C. A. 1909
Edson, Norman L. 1906
Ehrman, Joseph S. 1913
Ettenson, Isidore Z. 1908
Eickenburg, Phillip 1911

Fiske, George Wallace......1905	Newson, Archie Thomas.....1916
Flanagan, Francis J.........1906	Ott, Conrad Louis...........1916
Ford, Thomas Cecil.........1909	Pacyna, Arnold 1908
Foy, Edgar Allanson 1916	Palmer, Roger Carl.........1915
Friedman, Edw. Isaac.......1917	Pearson, Albert 1919
Friedman, Raphael M........1911	Perrine, Arthur 1909
Fryburg, Warren F.........1913	Pirrie, Peter G..............1913
Furay, Connel J.............1913	Pollak, Ernest 1908
Geldmeier, Henry Fred......1919	Quien, Ernest Louis 1903
Given, Louis Elazar.........1917	Rawson, H. Boyd...........1903
Goldberg, David 1911	Richards, T. E., Jr. 1909
Graff, Herman Walter......1900	Roleson, Edw. Phillips 1912
Griffiths, Francis H.........1911	Ross, Bernard Ludwig......1916
Hackett, James Leo.........1908	Rosenthal, Henry L.........1910
Hamilton, Warren H........1916	Ruede, E. M. 1910
Harwood, Edward Thomas..1902	Schmidt, Clarence G.........1914
Hazen, Fred George........1912	Schmidt, Fred 1912
Hibbard, Lewis Edwin......1915	Schreiber, Ernest Frederick..1915
Jensen, Raymond F..........1911	Schumacher, Joseph N.......1906
Jones, Clarence Ira..........1905	Schwachtgen, Edw. Chas....1920
Jones, Harold W............1907	Sherman, Max Albert.......1915
Kaempfer, Albert 1903	Sherman, Stanley B.........1903
Kappes, Edward F..........1898	Sleezer, Frank Walter.......1907
Kinnally, Raymond Wm....1916	Smely, James 1920
Knapp, Morris Jason 1904	Snowden, Chas. Rossiter.....1905
Kopa'd, Charles 1913	Stanton, Gustav Jr. 1907
Kuehne, John H.............1911	Stark, Andrew Gordon......1915
Larson, Reuben L...........1908	Summerfield, Myron L......1917
Laurence, Victor E..........1908	Tarvell, Clarence L..........1899
Levinson, Mark Bertram 1917	Tellin, William G............1911
Lurvey, Dave 1907	Tyler, Alva Warren........1905
McBurney, Edw. Jr..........1905	Urson, Frank J. Jr..........1909
Markel, Charles Hill.........1917	Vey, Frank Eugene.........1905
Martin, Robert Cloughan....1900	Weisskopf, Maurice J.......1903
Meyer, Eugene Daniel......1906	Wendt, S. J. W.............1903
Mieczkowski, Thaddeus K...1915	Wickersham, Edw. J........1904
Miller, Joseph V............1916	Wight, Robert Adams 1907
Moran, Charles Egan........1906	Wilson, Robert Lee.........1915
Morrison, Ralph D..........1906	Wolfe, Edw. John..........1907
Naglestock, Edwin H.......1898	Wright, J. C................1914
Narozny, Joseph Stanley....1912	Yoshida, Henry T...........1912
Nelson, C. J................1907	Zillmer, Emil G. 1913

In his remarks on public speaking, W. J. Bryan has declared clearness of statement, condensation, belief in your cause, apt illustration, dramatic question, and the character of the orator are six important points.

BOOK NOTES

MECHANICAL ENGINEERING

BUTLER, EDWARD—*Oil Fuel.*

A treatise on relative cost, means of application and fields open for its introduction, treated in a concise manner.

ELLIS & MEIGS—*Gasoline and other motor oils.*

Complete review of the various processes of refining, testing and cracking. Diagrams and many references to important patents.

ELECTRICAL ENGINEERING

MAGNUSSON, C. E.—*Alternating currents.* New ed.

Discussion of the fundamental principles of alternating currents. Graphic diagrams are employed to show relation between physical concepts and algebraic equations.

SMITH & CAMPBELL—*Automatic telephony.* New ed.

Comprehensive treatise on automatic and semi-automatic systems. It covers European as well as American systems.

CIVIL ENGINEERING

GILLETTE, H. P.—*Handbook of rock excavation.*

Manual of the best modern practice in drilling and handling rock of all kinds. Illustrates latest machines and methods.

HARGER, W. G.—*Location, grading and drainage of highways.*

This volume treats the road problem from the standpoint of the constructing engineer. It is the first of a series of four.

CHEMICAL ENGINEERING

AUDLEY, J. A.—*Silica and the silicates.*

"Comprehensive outline of the occurrence and uses of these substances, for the general reader and the beginner."

GETMAN, F. H.—*Outlines of theoretical chemistry.* Second ed

Text for beginners in theoretical or physical chemistry.

HAMOR & PADGETT.—*Technical examination of crude petroleum*

This volume presents the methods now used in technical examination and makes available to chemists and beginners the manner of applying the physical and chemical tests recognized as essential by technologists.

LINDGREN, W.—*Mineral deposits.* Second ed.

Description by class and type example of the occurrence and

origin of principle deposits of metallic and non-metallic minerals.

PROCHASKA, E.—*Coal washing.*

A systematic description of modern practice in coal washing. Gives necessary information as to choosing the apparatus.

OF GENERAL INTEREST

BOK, E. W.—*Americanization of Edward Bok.*

"The fascination of success hangs about this intimate account of a Dutch immigrant boy—of the work he did and the people he knew."

GIBBS, P. H.—*Now it can be told.*

Inside stories of the feelings and military blunders not published in the war correspondence.

IRWIN, WILL—*"The Next War."*

"It is a book of cold scientific facts, observations and plain figures."

ROSS, E. A.—*Principles of sociology.*

Understandable to the interested lay reader and instructive to the specialist.

STRACHEY, L.—*Queen Victoria.*

An interesting story of Queen Victoria, also a good picture of other interesting characters and the period.

SANITARY DISTRICT WORK

During the year 1921 the sanitary district of Chicago started and has completed sixty-five per cent of the construction of the Calumet sewage treatment plant located at 125th street and Cottage Grove avenue. This plant will purify the sewage of the entire district lying south of 87th street, when completed. It is expected that one section can be put in use by the first of July. It has completed the Calumet pumping station, which will pump the sewage of the district south of 87th street to the treatment plant, and from the plant in the Calumet-Sag canal.

It has completed the Calumet auxiliary power plant, consisting of four 750 horsepower Diesel oil engines to provide stand-by power to operate the Calumet and 95th street pumping stations. It has completed sections 8 and 9 of the Calumet intercepting sewer and section 13 of the Calumet-Sag channel.—Annual Report, 1921.

The Armour Engineer

VOLUME XIII MARCH, 1922 Number 3

THE CALUMET STATION OF THE COMMONWEALTH EDISON COMPANY

WILLIAM F. SIMS, '97 E. E., '03

Field Engineer, Generating Stations, Commonwealth Edison Company.

The Calumet Generating Station, which is located on the west bank of the Calumet River at 100th street, is the latest addition to the system of the Commonwealth Edison Company.

This station is designed for an ultimate capacity of six 30,000 kw, 12,000 volt, 60 cycle turbo generators. The present installation consists of two units, together with the necessary building, boilers and coal handling equipment. The design is, in several particulars, somewhat of a departure from the Company's present power stations, both in the boiler room arrangement and in the electrical installation.

The present boiler installation consists of seven Babcock & Wilcox water tube boilers, which have sufficient capacity to operate both units at full load. Space is provided for four boilers per unit. The boilers are arranged on either side of a longitudinal firing aisle with ample space between the two rows of boilers. The skylight over the firing aisle, between the overhead coal bunkers, is so arranged as to give exceptionally good light and ventilation. These boilers, which have 15,000 square feet heating surface each and which normally operate at 350 pounds per square inch pressure with 200 degrees of superheat, are equipped with Babcock & Wilcox superheaters and economizers. The stokers, two per boiler, are of the Coxe type, designed for forced draft and are driven by a 2 h. p. 230 volt direct current variable speed motors, which, incidentally, are the only direct current motors used for power in the station. The space behind the boilers is considerably greater than has been the practice in the past and provides room for the installation of heaters and forced draft fans and motors. Two forced draft fans per boiler are installed in this space on the boiler room floor. These fans are driven by

50 h. p. Westinghouse 440 volt, 60 cycle variable speed motors. With each economizer there is installed an induced draft fan, driven by a 200 h. p. Westinghouse, 2300 volt, 60 cycle variable speed motor. The controllers for the draft fan motors are motor operated and are controlled by a bank of push buttons, which, with the controllers for the stoker motors, are mounted near the front of the boilers, together with the draft gages and flow meters. This arrangement permits the fireroom attendant to observe the draft gages and flow meters while making adjustments of draft pressures and stoker speed.

Coal is unloaded in the boiler room basement, thirty-two feet below the boiler room floor. The coal cars are brought in on a track running longitudinally in the space below the firing aisle and the coal unloaded by a coal handling crane, either into coal storage pits below this level, or directly onto a belt conveyor which carries the coal to the coal preparation plant. This plant, which has a capacity sufficient to handle the coal required for the boilers of three units, is located at the east end of the boiler house. A similar plant will be installed at the extreme west end of the boiler house when the plant is extended. The coal is delivered from the belt conveyor and is first screened, the larger lumps going into a coal breaker. The balance of the coal passes over another screen, which discharges the fine coal directly to the bucket elevators and the remainder to the coal crushers, to which is also delivered the coal which has gone through the breaker. This arrangement relieves the breaker and crusher of the duty of handling coal already sufficiently fine for use.

The coal is carried from this plant to two coal receiving hoppers at the top of the building by bucket elevators, one of which is now installed and provision made for a later installation of a second elevator. The coal receiving hoppers discharge directly to belt conveyors running longitudinally above the coal bunkers, which are of reinforced concrete, one set of bunkers being built directly over the stoker hoppers of each row of boilers. Coal is discharged onto these hoppers through sheet steel spouts which are provided with baffle plates to insure uniform distribution of coal across the stokers. Ashes are run off the back end of the stokers and are discharged into ash hoppers under the rear end of the boilers, from which they are dumped through pneumatically operated gates to ash cars on tracks in the basement.

In the present development, one of the units is Westinghouse

and one General Electric, the former being designed for 1200 and the latter for 1800 r.p.m. The turbo generators are installed in one row in the north portion of the turbine room on a common longitudinal center line. The generators are rated at 30,000 kw. and 35,300 kva at 85 per cent power factor.

Exterior of Calumet Station.

The Westinghouse unit is equipped with Westinghouse and the General Electric unit with Worthington condensing equipment. Both circulating pumps are motor driven, being direct connected to 800 h. p. 2300 volt, 60 cycle Westinghouse slip ring motors with remote control starting equipment, designed to permit variable speed as required to maintain the proper degree of vacuum with the highest possible temperature of condensate. Each unit also has two sets of condensate and vacuum pumps, one steam driven and one motor driven. On the Westinghouse unit the condensate and vacuum pumps are separate and on the General Electric unit, in each case, these pumps are combined on a single shaft.

Circulating water is taken from the Calumet River through a crib house, in which are located revolving screens for removing rubbish and debris. From the crib house, the water is carried to the intake tunnels under the turbine room basement through an open flume. Two tunnels have been provided, one for the

first three units and one for the last three units. A common discharge tunnel carriees the water to another open flume which discharges into the river. On account of the fact that at times the flow of the river reverses, provision has been made for the installation of gates in the crib house, so that the intake will always be taken from up stream, and the water discharged down stream.

Large openings have been left in the turbine room floor south of the machines, directly over a track at the basement level, which permits the unloading of apparatus direct from cars by a 125-ton Whiting traveling crane.

Opening off of the north side of the turbine room basement, below the boiler room, is the pump room. In this location are installed three turbine driven and one motor driven boiler feed pumps, two house service pumps, one motor driven boiler wash pump, the water softening plant and other steam auxiliaries. All of this apparatus is convenient of access by the operator in charge of the turbine room auxiliaries, as are also the generator air washers, which are installed immediately adjacent to the generator foundations.

Adjoining the turbine room on the south is the transformer house, the first floor of which is level with the turbine room basement and the third floor at the turbine room grade. Directly south of the transformer house is the switch house, which cantains the busses and switching apparatus for handling the output of the station.

The switch house arrangement, which is a radical departure from that in any existing stations, is designed on plans originated by Mr. B. G. Jamieson, A.I.T. '97, Engineer of Inside Plant, under whose direction the entire electrical design was worked out. This design provides for complete separation of phases and practically eliminates the danger of phase to phase short circuits, which, on a system of the size of that of the Commonwealth Edison Company, is a consideration of very great importance.

In the older stations, two sets of main busses are carried longitudinally on either side of the switch-house with all three phases adjacent, although in separate compartments, with line busses running transversely and connected at either end to the main busses through oil circuit breakers, with three outgoing lines connected to each line bus. These line busses are carried on transverse concrete walls, spaced approximately on eight foot

centers. The oil pots of the circuit breaker are located on the floor above with the operating mechanisms on the upper floor.

In this station, the busses are carried on three longitudinal walls spaced on 16-foot centers, with one phase only on each wall. The two main busses are installed one on either side of each of these walls below the ceiling of the first floor. The line busses are carried in a similar manner on either side of these walls at the ceiling of the second floor, upon which the oil pots of the oil circuit breakers are installed, the mechanisms being located on the third floor.

This arrangement necessitated a switch mechanism which would simultaneously operate the contacts in three oil pots spaced 16 feet apart, which is a decided departure from present standard switching equipment. Owing to the large capacity of the Commonwealth Edison system, switching equipment now on the market was not considered to have sufficient rupturing capacity under short circuit conditions, and the manufacturers were called upon to design oil circuit breakers of larger capacity which would meet the physical conditions in this station, and also to provide disconnective switches which could be operated from the mechanism floor, either manually or automatically in connection with the switch mechanism. These disconnective switchees are equipped with back slips which are connected to disconnective switches on the mechanism floor through high voltage cables for use in grounding or for high voltage testing as required.

On the specifications laid down by the Company's engineers, the General Electric Company has designed a switch known as type FHD 17, which incorporates the foregoing features. Twenty-nine of these switches have now been installed complete and additional switches will be installed later to complete the switching equipment for two units. All generator switches and group switches between the line busses and the main busses and the switches supplying the auxiliary power bus and the high voltage transmission line transformers are of 2,000 ampere capacity. All switches for 12,000 volt outgoing lines are of 600 ampere capacity.

In the connections between the line switches and the underground cables, one-half ohm current limiting reactors have been installed on the first floor. The cable terminal bells in the switch house basement are mounted on the center wall with connections to the other two walls carried in fibre conduit on the basement

ceiling. The outgoing cables are carried out to the system through an arrangement of underground conduits and man holes, so designed that the necessity of crossing of cables in the station due to line changes and cutovers is entirely eliminated.

The station will be operated in two sections which are connected together through two sets of 1,000 ampere one ohm reactors in series, with a 2,000 ampere bus tie switch between these reactors. Switches are also installed between the busses and these reactors. The Calumet Station busses are connected to the Fisk Street Station busses through two 3 conductor 350,000 c. m. lead covered underground cables, designed to operate at 33,000 volts, each line having a capacity of 15,000 kv-a. These lines are fed through two 15,000 kv-a. 12,000-33,000 volt, G. E. transformers, connected to the station bus through 800 ampere reactors. At the Fisk Street end, the voltage is stepped down through a similar installation of transformers. This is the first installation of three conductor underground cables at this voltage.

The auxiliary apparatus in this station is motor driven, except where, for reason of steam economy, steam driven apparatus has been used. All auxiliary motors of 100 h. p. or over are on 2,300 volt service and those below 100 h. p. on 440 volt service, with the exception of the stoker motors which, as previously noted, are direct current 230 volt on account of the extreme range of speed variation required.

The transformers supplying the motor driven auxiliaries are fed from a separate 12,000 volt bus, which is connected to the switch house busses by two 1,000,000 c. m. services. These services to the auxiliary power bus are connected to either side of the bus tie switch between the bus reactors. With this arrangement, there is always a reactor between the auxiliary power bus and the main busses, which will materially reduce the liability of losing the auxiliaries due to system disturbances.

The auxiliary power transformers are of such size that when the entire entire installation has been completed, there will be sufficient transformer capacity of each voltage to carry the auxiliary load with one transformer available as spare. In the present installation, two 4,000 kv-a. 12,000-2,300 voolt and two 2,000 kv-a. 12,000-460 volt Pittsburgh transformers have been provided for supplying auxiliary power, with two 12,000-230 volt transformers for lighting service. These transformers are installed in compartments in the transformer house, opening into the turbine

room basement. The two 15,000 kv-a. 33,000 volt transformers for Fisk Street tie lines are also installed in this location. All transformers are mounted on trucks running on rails which permit the transformers to be readily moved into the turbine room basement in case of transformer trouble, where they are accessible to the turbine room crane.

The 2,300 volt auxiliary power center is located in the transformer house at the turbine room floor level. All service switches for 2,300 volt motors are installed in this location and arranged for remote control from the motors. No starting compensators

Turbine Room, Calumet Station.

are used with these motors. When the starting push button at the motor is closed, the motor is connected to a 1,150 volt bus, fed from half taps on the transformers, through a starting switch which remains closed until the starting current has dropped to a predetermined value, at which time, an accelerating relay operates and opens this switch. Auxiliary contacts on the starting switch complete the closing circuit on the running switch after the starting switch is open, thus automatically throwing the motor over from starting bus to the 2,300 volt running bus. The closing of

the stop button at the motor opens the running switch when it is necessary to shut the motor down. The control equipment of the variable speed motors is so arranged that when the motors are shut down, all resistance is automatically cut in to the motor circuit, thus leaving the equipment in condition for normal starting.

The 460 volt transformers are connected to a main switchboard in the transformer house, from which the 440 volt motors in the south portion of the building are fed. This board is connected by tie cables to a sub-power board, in a space opening off of the north side of the turbine room below the boiler room floor, which supplies the forced draft fan motors and the 440 volt motors in the turbine room basement. A second sub-power board is located at the east end of the boiler room which supplies all of the motors for the coal handling equipment, and is interconnected with the other 440 volt switchboards through tie cables.

Owing to the length of the tie lines, to the Fisk Street station, it was found that the charging current of these cables was such that it would necessitate the installation of an excessively large alternating current testing equipment. For this reason, apparatus for direct current testing has been installed. This consists of a Kenotron testing set with a range up to 100,000 volts at ½ ampere, which is very much less capacity than would have been required for alternating current testing.

High voltage cables are run from this set to the 33,000 volt high voltage transformer compartments and to the mechanical floor of the switch house, the latter being connected through knife blade switches to the cables from the back clips of the disconnective switches, for testing 12,000 volt lines.

Two hundred and thirty volt direct current control is used throughout the station, the operating bus being supplied from a 1,500 ampere hour storage battery, to which is also connected the feeds for the direct current stoker motors. The 200 kw motor generator sets for charging the battery have been installed, one of which is normally in operation on the battery circuit.

Although work was started on the excavation in the summer of 1920, due to unavoidable delays, it was not possible to start the installation of the electrical equipment until August, 1921. In spite of this delay, Unit No. 1 was placed in service December 22, 1921, and Unit No. 2 on February 15, 1922.

Three Armour men were closely identified with this station,

Mr. B. G. Jamieson of the class of '97 having the general direction and responsibility of the electrical design, Mr. J. W. Baring of '16 being in charge of all electrical checking and testing and placing of apparatus in service, and the writer had the general direction and supervision of the work for the Engineering Department.

DECISION AND EXPERIENCE

It is decision or the lack of it that makes the difference between first-class and second-class men.

No man is fit to command an army or even a company of infantry unless he has decision.

Hesitation in time of war is fatal. It is dangerous and destructive in times of peace.

No man can always make up his mind quickly and be sure he is right every time.

But the man who does this oftenest is the man who gets furthest in the world.

All important leaders of action or thought are men of decision.

This is particularly true of executives who have many men under them. To such men hesitation means lost time—hundreds of hours of it—and is not to be tolerated.

But be very careful, in cultivating decision, to base it on experience.

It will be anything but an advantage to be able to make up your mind quickly if you make it up wrong every time.

We ought not to hesitate more than half an hour over the choice of a suit of clothes or more than ten seconds over the choice of a necktie.

Yet even to make trivial choices such as these requires a knowledge of ourselves which is not lightly acquired.

Learn to decide, for decision means efficiency. But learn to decide right. Base decision on thought and experience and it is not very likely to go wrong.—Selected.

COMMENTS ON ENGINEERING SPECIALIZATION

R. M. Henderson, '02 E. E. '06
Vice-President, Dwight P. Robinson & Co., New York, N. Y.

In glancing over a register of graduates of the Institute to see what had become of the men of my time at Armour, I was struck with the fact that a number have wandered a considerable distance from the field of their undergraduate studies. Pursuing this thought further, a glance down the column of the register will show that this has been the experience of a sufficient number of men to raise the question as to the extent to which it is wise to specialize when laying out courses for engineering training. In these days when one hears so much of highly trained specialists there is a temptation to feel that it is necessary to become an expert in the highest degree in some line in order to meet the competition in the business world.

Lord Shaughnessy, who worked up from the bottom to the top of the organization of the great Canadian Pacific Railway Company, was recently quoted as saying that in his opinion, there are better opportunities for young men today than there were forty or fifty years ago when he was starting out. I think it would be freely admitted that he is in a most excellent position to pass an opinion on such a matter. Certainly he was not a specialist in his underlying training and whatever specializing he may have done was after he got into his chosen field of endeavor.

Every undergraduate has to lay his course in the light of his own personal knowledge or lack of knowledge, supplemented by the opinion of his parents, or business friends, and the advice of those qualified to direct his selection of a course. The romance attached to some of the gigantic engineering accomplishments is the magnet that attracts some. The more practical considerations of a well-ordered domestic life appeal to others, but the emphasis that has been laid upon the selection of a definite line on which to specialize has been considerable and seems open to debate.

During the past twenty years in my own experience I have spent less than 5 per cent of my time along electrical engineering lines, which was my particular specialty. The companies with which I have been associated have employed many thousands of

engineers during that time and I have had active contact with graduates of practically every recognized engineering school in this country and Europe.

Aside from the opinion of many of these men, there is the experience of other graduates of technical schools which may start some readers thinking to the extent of provoking comment along this general line of thought. Circumstances and personal taste have apparently had more to do with the careers of the men than have the particular branches of engineering which they studied at college.

One electrical engineer is now in the cigar business; a mechanical engineer is selling electrical suppplies; one electrical and one chemical are farmers; a number are executive officers of fire insurance companies ,although they did not all take fire protection engineering. Another is vice-president of a bank. Several mechanical and electrical men are in the building construction business, which has more to do with civil engineering than the mechanical or electrical courses in which they specialized. These instances may indicate the point of these comments and the more you study the register of graduates the more you will realize that opportunity and your own ability will cut such an important figure with your future that specializing to a high degre in one branch of engineering may prove to be a handicap rather than an advantage in later years.

The man who will continue academic study after he is in the business world is the exception, as few men will make the necessary effort to overcome the many reasons or excuses for not burning the midnight Mazda. There are business, social, or domestic claims upon their time. Local community life makes heavy demands on the better type of citizen. Most of the men I have talked with, graduates of technical institutions, agree that among other regrets are their shortcomings in the use of the English language, and their inability to discuss for more than five minutes subjects unrelated to shop, batting averages, and prohibition, and in one form or another, they express their regret at their failure to generalize more in their technical studies while at the same time doing the minimum work necessary for the definite courses leading to an engineering degree. Following out this thought of generalizing does not necessarily mean the taking on of a heavier load as an undergraduate, for it is recognized that the courses are all full and exact about all the time available,

but it does mean an entirely different attitude towards what may be called "secondary studies" such as the civil and mechanical work that go with the electrical course, and the economic and cultural studies that are part of all courses.

In particular the inability to properly use the English language is a characteristic short-coming of the average engineer who has come under my observation. A man who can write a report that is fit to place in front of a banker or business man of education is so rare that he is eagerly sought by any organization handling that class of work. There are plenty of engineers who can get their facts together but few who know how to properly express them.

This is a very large subject on which educators have been more or less at variance since the beginning of higher education. The views here expressed are far from conclusions in the matter, but will, I hope, result in further comments by others of the Alumni whose experiences have perhaps emphasized other phases of the same question. If such a discussion should result, service may have been rendered to some who are now trying to select out of many pages describing courses in engineering, those subjects which will be of the most use to them in after years.

COST ACCOUNTING

GUY FOOTE WETZEL, '15, M.E. '18

During the World War, when nearly every line of manufacturing was working to capacity, there were many cost and planning system installations. At that time, expense was no object, and many business executives figured if they did not spend the money they would have to pay it to the government for taxes of various kinds. Then too, there were many "cost-plus" contracts, where the higher the cost the higher was the profit, until the later contracts which gave the manufacturer part of the savings below a certain maximum price.

Where contracts were let at a price in any way dependent on costs to be determined later, the existing method of cost accounting had to meet the approval of the government or be revised to do so. This was a good thing in a number of cases, as it forced people to know their costs, who formerly ran their plants more or less in the dark as far as costs were concerned, except for the annual profit and loss statement based on physical inventories.

The passing of the income and excess profits taxes which apparently are with us to stay in some form, made it necessary to keep cost of manufacturing records that may not have been kept before.

The indications are that we have gone through the worst of the business depression, which started toward the end of 1920, and will see a gradual resumption of business, with keen competition for orders, and prices set as low as possible to tempt buyers.

Where during the war inflation, expense was not spared to get costs and operating information, we find that now this expense is cut to the minimum. This makes a method of cost accounting that eliminates considerable work and still gives valuable detailed information, especially interesting.

Mr. A. W. Torbet, Certified Public Accountant and Industrial Engineer, with whom the writer has been associated, recently proposed a cost accounting plan which has some new features, and was installed in a large manufacturing plant near Chicago. The following discussion takes up this plan and compares it with the usual cost accounting methods in manufacturing lines.

The work of handling income and expenditure data is commonly split between the Accounting Department and the Cost Department. The former usually handles sales and finance records

and the general books, while the latter accounts for manufacturing expenditures. We will not dwell on general accounting which is a broad subject in itself, but confine ourselves to cost eccounting.

The results to be obtained by the Cost Department are:

(1) Determining unit costs of goods produced.

(2) Determining cost of manufacturing, for executive control purposes, and accounting records, to account for expenditures for labor, material, supplies and expenses, and to get information for reports to factory executives.

Unit costs are made up of three elements: labor, material and burden (or overhead, or indirect expense.) Cost of manufacturing is made up of payroll, material used, supplies used, and expenses of various kinds. It is obvious that cost of manufacturing for a given period should equal the sum of the products of goods produced times their respective unit costs (assuming that work in process is the same at beginning and end of the period.)

When we speak of "labor" as an element of a cost (i.e. unit cost) we ordinarily mean direct labor or as it is sometimes called, productive labor. This is labor performed directly on the product such as machine operating, assembling, or molding. "Material" refers to the material entering into the product such as sheet steel, castings, finished parts. "Burden" is an amount which is supposed to cover the cost of everything else entering into the production of the article. It is made up of indirect labor (sometimes referred to as non-productive labor) supplies, maintenance of equipment, administrative salaries, power, depreciation, taxes, insurance, building charges, etc. Thus it will be seen that the amounts of money making up the burden amount for the plant, come from several distinct and unrelated sources, which are payroll (indirect and administrative); inventory of supplies, inventory of direct materials (when used for indirect purposes; bills for service such as laboratory work done by outsiders, bills for electric power, gas, water, building or ground rent, etc: charges originating in the Accounting Department and charged into factory burden to cover depreciation, real estate and personal property taxes for the factory, liability, fire, use and occupancy, cyclone, riot and other insurance, amortization, if any, etc. These charges are made monthly, being equal to one-twelfth of the estimated yearly charges, and are offset by credits to reserves for the respective items.

Labor is handled through weekly, daily or job time cards, often

distributed and summarized by the Powers & Hollerith electric sorting and tabulating machines. Material in all plants boasting even a rudimentary factory control system, is handled by means of requisitions, which also can be handled by the machines mentioned above. These two elements, making up prime cost, are handled in fairly well standardized ways, regardless of the particular cost finding and cost accounting methods used. Inasmuch as burden is the variable factor, and the important differences between all cost accounting plans are in the methods of handling burden, we will confine the balance of this paper to that element.

In costing finished work, the burden is added to prime cost, based on one of several plans the principal ones of which are: percentage of direct labor, charge per direct labor hour, charge per unit of production ,and machine hour rate.

Now let us turn to the second general function of the Cost Department, that is, accounting for all manufacturing expenditures.

Burden, as previously mentioned, is a mixed item, made up of labor, supplies, expenses and book charges.. Analyzing these components further we find that some of them are made up of items that are controllable charges and some of uncontrollable charges. Also, some of the items will vary as the volume of production varies, and others are fixed amounts regardless of the volume of production. Therefore, it is desirable to separate as near as possible the controllable and variable burden from the uncontrollable and fixed. In general, the controllable charges vary to a large degree as production volume varies, and uncontrollable and fixed charges vary but little with volume of production. One of the most important parts of the controllable burden is indirect labor. It is desirable to have labor charges segregated from the other charges in order to retain a clear analysis of payroll as part of cost of manufacturing, for liability insurance reports,, for auditing purposes, for income tax reports, and reports to the factory management.

With these considerations in mind, the logical divisions of manufacturing cost are:

(1) Direct Material
(2) Direct Labor
(3) Indirect Labor
(4) Indirect Expense
(5) Apportionable Charges.

Indirect labor (3) should include all indirect and supervisory labor up to the factory administration section. Indirect expense (4) should include operating supplies, maintenance supplies, power, small tools, etc. Apportionable charges (5) should include administrative salaries, depreciation, insurance of all kinds, taxes, building maintenance, building heating.

Indirect labor for the plant can all be charged directly to the manufacturing departments except a certain amount made up of general maintenance, heating labor, care of buildings and grounds, etc, which serves the plant as a whole. The latter will be charged to what might be called a general or plant department.

Indirect expense should be charged in a similar way, that is, to manufacturing departments where possible and the balance to the general department.

According to what is considered good cost accounting, the separation of indirect labor and indirect expense is not generally made, but these are charged to the departments in some mixed and some unmixed amounts. For example, supervision and general labor are unmixed, but maintenance is made up of both labor and supplies. The charges to the general department are added to the fixed expenses (depreciation, taxes, insurance, etc.) and the total distribution to the manufacturing departments on an estimated percentage or a factor based on equipment investment, man hours worked, number of employees, or composite factor. By the time this has been worked out in detail, practically all the component charges have lost their identity, and the way many installations have been put in, it is a difficult auditing job to trace back and re-identify the elements in order to know just what the manufacturing expenses consisted of for the year.

The burden rate multiplied by man hours, direct labor, production units, etc., whichever applies in a given case, is the absorbed or earned burden. This compared with the department burden charges, leaves a debit or credit balance. which should be very small at the close of the year, and is closed into Profit and Loss.

The new method previously mentioned has for its objects (1) charging to the departments only the controllable and variable expense (2) building up cost of manufacturing accounts which will tie in perfectly with the general ledger (3) detailing a complete analysis of manufacturing expense (4) eliminating considerable clerical work (5) obtaining data for monthly Profit and Loss Statements, and Balance Sheets.

At the end of the month, when requisitions, time cards, and expense charges are all in the Cost Department, the manufacturing department charges are made up. These charges will be practically all items that can be controlled by the foreman, and that vary with production volume. The fixed charges will not be prorated, but will be charged to an account called Apportionable Charges, for the plant. Service department charges such as stores, receiving, shipping, etc., labor and supplies will be charged to these departments respectively and not split up between the manufacturing departments. There is a valuable control feature here, in that the foreman is held responsible for the expenses of his department, and loses the alibi so often put forward, that he can't control the depreciation and other fixed items usually charged in.

Some cost accountants may take issue with the foregoing paragraphs, but the question simply amounts to this. "Shall the manufacturing departments be charged with rational plus arbitrary charges over which the shop management has no control, or with the rational charges only?"

The Apportionable Charges Account will be a general ledger account, and will be handled by the accounting department. Since it is necessary to get the fixed burden charges into the cost of manufacturing, the estimated amount of these charges plus the estimated manufacturing departments charges (not including any prime cost) will be pro-rated to the manufacturing departments as a matter of statistical record for the purpose of setting up the burden rate for the coming six monthe or year. This rate will be used for costing purposes as a unit rate, but for cost accounting will be made up of three parts (1) direct burden allowance to cover indirect labor and indirect expense (2) service department allowance, and (3) apportioned expense allowance. Thus in a plant where the direct labor hour rate is used, the first part of a given department's rate multiplied by the direct labor hours should absorb the direct burden, averaged over the fiscal period. The second part of the rate should absorb the departments estimated share of the service department's direct burden, while the third part should absorb the department's estimated share of the apportionable charges. This latter absorbed amount we will call "Apportioned Expense." The total of the amounts absorbed by the various manufacturing departments will be entered in a credit account in the general ledger, called "Apportionable Charges

Earned." The difference between this account and the corresponding debit account will give the unabsorbed or over-absorbed amount for the plant as a whole which is an indication of Production Volume Efficiency and a valuable guiding figure for the general management. In similar way, the direct burden unabsorbed for each manufacturing department and the plant or division service charge unabsorbed will be determined.

As far as the factory and cost department are concerned, the amount of the fixed burden will be the amount absorbed, that is, instead of trying to charge in a number of items distributed on an arbitrary basis, we will only charge the second and third parts of the burden rate times the direct labor hours. The direct burden will be charged in at the actual figures. This brings in another valuable control feature. The fixed burden handled as above in the factory will vary in proportion to the direct labor and thus follow very closely the volume of production. Therefore, variations in costs will be almost entirely due to variations in controllable items, and will enable the management to catch and eliminate causes of increase. To illustrate the value of this, suppose a plant that had been operating at 100 per cent capacity cuts its production to 50 per cent. The burden cost per unit, if the fixed burden is charged directly into costs, immediately jumps 50 to 100 per cent depending on the ratio of fixed and variable burden. At a time like this, it is very important to watch the variable burden, and make such cuts as are necessary, and will not sacrifice too much of the organization, to keep the unit costs for direct burden from rising to a dangerous point. Conversely, if the production is increased, costs must be watched to see that there are no increases and there should be a small decrease. The management will know without any special report that costs will go up with lower production, due to fixed charges, but this is unavoidable. Thus it is doubly important to watch for avoidable increases.

Manufacturing as a business is full of pitfalls for the unwary, as is shown very clearly by the number of failures in this line every year. One common one, and many plants have found it out to their sorrow in the last few years, is allowing unabsorbed burden to get into the inventory and stay there until the end of the year, when there is a shrinkage in inventory that is sometimes serious. This can be avoided by charging into Work in Process the actual material, direct labor, actual direct burden,

and standard apportioned burden, and then for work completed, crediting work in process with the same items. The Finished Goods inventory will then be charged with the standard costs for goods produced, the unabsorbed amount being charged to profit and loss at the end of the year. It is apparent that any cost accounting plan from the worst to the best will not in itself change in any degree the amount of money a firm makes, but information from a sound and properly functioning cost system is like a good tool,—very valuable if made use of.. There are two good reasons for spending money to find out what it costs to run a factory, and the unit costs of goods produced: (1) to get necessary records, and (2) as guide in management. Costs are very sensitive, and will increase at an alarming rate for what at times appear to be very trivial causes.

Now, in order to illustrate in a concrete way what we have been discussing, let us assume a set of conditions which will represent a fairly common situation, viz: a factory manufacturing small gas engines, with a foundry division divided into melting department, molding department, finishing department, core room, and pattern shop, and a factory division with the following departments: machine shop, assembling shop, nickel plating and polishing shop, stores and receiving, packing and shipping. There would also be a factory administration division consisting of factory executive department, cost department, purchasing department, planning department, plant service department, truck operating department, engineering department, employing and welfare department. The executive and sales division would ordinarily consist of the general officers, accounting department ,sales department, and any special departments required by the particular business. The latter division does not affect cost of manufacturing ordinarily, and so will not be shown in the factory accounts. We will further assume that the factory is using a rate per direct labor hour in costing the manufactured product.

As the classification of accounts often will expedite or retard the work of keeping the accounts and classifying charges, as well as affecting the way the information comes into the cost department from the factory, we will carry through a numbering plan that has been found very satisfactory:

DEPARTMENT ACCOUNTS

10 Foundry Division

11 Melting	12 Molding
13 Finishing and Cleaning	14 Core Room
15 Pattern Shop	16 General

20 Factory Division

21 Machine Shop	22 Assembling
23 Plating and Polishing	24 Stores and Receiving.
25 Packing and Shipping	26 General

30 Factory Administration

31 Factory Executive	32 Cost
33 Purchasing	34 Planning
35 Plant Service	36 Truck Operating
37 Engineering	

40 General Plant.

The manufacturing account numbers will be made up of four digits, the first two being the department number, the next to the right the charge classification, and the last (in the unit's place) indicating the detail charge. Ciphers appearing in the units, tens, and hundreds places, indicate department, division and plant totals, respectively. The general classification is as follows:

0010 Foundry Melting Cost
0020 Direct Material
0030 Direct Labor
0040 Indirect Labor
0050 Indirect Expense
0060 Apportioned Expense.

Direct Labor and Direct Material are fundamental classes and will be handled in the usual manner.

Indirect Labor will be all the labor usually coming under that head ,and will be charged to the department for which the work is done regardless of whether it is included in that department's payroll or is transfer labor from some other department. As long as the labor charges and the payroll agree it is not of special importance to know the amount of transfer labor, and the incidental clerical work can be saved. The source of these charges will be the Indirect Labor tickets, charged against standing order numbers.

Indirect Expense will consist of charges for supplies and for service, in fact all the factory charges which do not come from direct material inventory or payroll.

Indirect Expense plus Indirect Labor will be equivalent to variable and controllable burden.

Apportioned Expense will only be charged against the departments which carry a burden rate, and will be the amount obtained by multiplying the apportioned expense part of the burden rate by the number of direct labor hours for the period.

Apportionable Charges, a general ledger account, will include each month, one-twelfth of the annual charge as estimated in setting up the reserve for depreciation, taxes, and insurance, and also the charges for building maintenance, factory administration, truck operation, grounds expense, etc. This account will be used for three purposes,—(1) to determine the hourly charges which become part of the manufacturing departments' burden rate, (2) to determine the unabsorbed portion of Apportionable Charges by comparison with Apportioned Expense, (3) to determine the actual cost of manufacturing.

The amount of Apportionable Charges will remain in the General Ledger, closed into Cost of Manufacturing control account. As far as the factory is concerned, only the absorbed portion of Apportionable Charges will be used, i.e. Apportioned Expense.

In the General Ledger there will be only two cost accounts, Cost of Manufacturing, and Apportionable Charges. There will be sub-ledger accounts giving analysis of divisions, controlled by the former and accounts for each class of charges controlled by the latter. There will also be sub-ledger credit accounts for recording Apportioned Expense. The difference between this account and Apportionable Charges for the month will be the unabsorbed fixed burden, and should be reported to the management each month. The reason two accounts, one debit and one credit, are used is to accumulate the fixed charges until the end of the fiscal period.

ACCOUNT CLASSIFICATIONS

Cost of Manufacturing Ledger, Controlled by Cost of Manufacturing Account in General Ledger.

1011 Foundry Iron Melting Cost (Includes all foundry, direct material)

1030 Foundry Direct Labor

1040 Foundry Indirect Labor
1050 Foundry Indirect Expense
1060 Foundry Apportioned Expense
1001 Foundry Work in Process Credit.
2020 Factory Direct Material
2030 Factory Direct Labor
2040 Factory Indirect Labor
2050 Indirect Expense
2060 Apportioned Expense
2001 Factory Work in Process Credit.

Apportioned Charges Sub-Ledger Accounts:

4100 Fixer Charges
 4101 Depreciation
 4102 Taxes
 4103 Insurance, Etc.
4200 Building Charges (Maintenance, Heating, Etc.)
4300 Grounds Charges
4400 Administration Charges
4501 Apportioned Expense Credit (Credit Account)
4502—Indirect Expense Credit (Credit Account)

Expense Ledger in which all charges are recorded that do not belong in either inventory or payroll, such as Power, Gas, etc., but are chargeable at the end of the month into one of the other expense accounts. The account should be cleared each month. 5000 Expense Ledger.

APPROPRIATE DETAIL ACCOUNTS

In order to illustrate the use of the numbering system, and give an idea of how the plan under discussion applies, the accounts are shown for a few of the departments.

DETAIL ACCOUNTS AND RUNNING ORDER NUMBERS

1110—Foundry Melting Cost
 1111 Pig Iron
 1112 Purchased Scrap Iron
 1113 Remelt Scrap Iron
 1114 Other Supplies
 1115 Cupola Labor
 1116 Other Melting Labor.
1200 Foundry Molding
 1231 Molding Direct Labor

1232 Pouring Direct Labor
1241 Cut Sand and Prepare Floors
1242 Maintenance Labor on Flasks and Portable Equipment
1243 Maintenance Labor on Machines
1244 Supervision
1245 Inspection
1246 General Labor
1251 Molding Sand
1252 Maintenance Supplies for Flasks, etc.
1253—Maintenance Supplies for Machines
1254 General Supplies
1255 Power.

2100 Machine Shop—Manufacturing
2121 Castings
2122 Steel Shafting and Forgings
2123 Manufactured Finished Parts
2124 Purchased Finished Parts
2125 Miscellaneous Direct Supplies
2130 Direct Labor
2141 Supervision
2142 Inspection
2143 Maintenance Labor on Small Tools and Portable Equipment
2144 Maintenance Labor on Machinery
2145 Miscellaneous Shop Labor
2151 General Supplies
2152 Inspection Tools, Gages and Supplies
2153 Expendable Small Tools
2154 Maintenance Supplies for Machinery
5155 Power.

By keeping the elements of burden separate as above, fewer accounts are needed, and better control can be maintained, because any excess costs are automatically localized without further analysis. The list shown herewith is suggestive only, to fit in with the assumed conditions. Melting Cost is kept separate, as one of the important things to watch in a foundry is the cost of iron at the cupola spout.

In making up the charges for the month, a work sheet will be used on which the information received from summaries of time

cards, material requisitions and Expense Ledger Debit Notices, will be recorded. This information should be recorded in permanent form in a Factory Ledger, which gives the dtailed analysis of all the Cost of Manufacturing Ledger. A summary of this data giving department totals under Foundry Melting Cost, Direct Labor, Direct Material, Indirect Labor, Indirect Expense, and Apportioned Expense, for each department, gives the management all the detail usually wanted. Any item that seems to be excessive can be analyzed by reference to the Factory Ledger, and in still further detail by reference to the time cards and requisitions should that be required occasionally.

The journal entries (that is, list of debits and credits from which the books are posted) are easily made up in the Cost Department, and from them and the sales data for the month, a Profit and Loss Statement can be made up, in connection with the information already recorded in the general books.

In most plants, the executives receive at the end of the month, a voluminous report, giving in great detail a lot of information from which it is difficult to get an accurate picture of the results of operation for the plant as a whole. Therefore, a Cost of Manufacturing Statement giving a few vital figures for each department, a Profit and Loss statement, and Balance sheet, covering not more than six or eight pages at the most, is more valuable than almost any other report, because it reflects a general picture. Where certain items need special watching, subsidiary statements may be of value, but these should be made brief, and be sent to the ones interested and responsible.

These considerations have been kept in mind in developing the plan described. The results of its use are,—clear analysis of the various classes making up the cost of manufacture, better coordination between cost and accounting records, elimination of considerable clerical work in pro-rating fixed charges, better control by the management.

The subject is almost too broad to be covered adequately in a short paper, therefore there may be some details that have been omitted or touched on too briefly. However, this plan has been worked out in detail, and practical applications made, which have proved it to be of value in plants large enough to warrant a cost department. Naturally, the plan as outlined will not fit every plant, but when built up around the conditions existing in a given factory will in most cases apply.

THE ELECTRICAL INDUSTRY AND THE ELECTRICAL ENGINEER

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In the electrical industry lies the chief field for the activities of the electrical engineer. This is quite natural and it should be equally natural to expect the electrical engineer to keep posted on the varied opportunities that this industry offers for his services. A large percentage of these engineers, however, do not keep adequately informed on electrical developments beyond the immediate range of their specialties, the result being a loss to the industry as well as to themselves. The young graduates just embarking on their professional careers as a rule have only a meager knowledge of just what this industry is and to what extent they and it can be of mutual service, while the undergraduates still struggling to get a grasp of fundamental electrical principles have, of course, a still more visionary conception of these relations.

Each of these three classes of electrical men can doubtless profit from a survey of this industry and of the trend of current electrical developments. The older men should benefit from a greater breadth of view and a revival of interest in all matters electrical. The young men meeting exceptional difficulties due to prevailing business conditions should rekindle their enthusiasm through a knowledge of past achievements and prospects of their chosen industry. The students who are often baffled by the intricacies of electrical theory should derive inspiration from knowing the importance of that theory to their future work.

ANALYSIS OF INDUSTRY ACTIVITIES

The electrical industry may be divided into three main groups of activities:

First—Those which render an electrical service to the public, in the supply of electrical energy for conversion to mechanical power, light, heat or chemical energy; in the supply of electrical transportation of persons or goods; or in the supply of electrical communication. This service group is generally known as the electrical public utilities and its subdivisions are commonly known as the central stations, the electric railways, and the telephone, telegraph and radio systems.

Second—Those concerned with the production and distribution of electrical commodities. This group is subdivided into producers (electrical manufacturers) and distributors, the latter being of two kinds, wholesale (jobbers) and retail (dealers).

Third—Those concerned with the design, construction and maintenance of electrical installations, both large and small. The principal division of this group is into consulting electrical engineers, wiring contractors, electrical maintenance contractors, and electrical inspectors.

The foregoing grouping is rough and overlooks a small amount of overlapping of functions that prevails. It also ignores the less important electrical activities and those outside of the electrical industry proper. In general, however, it represents this industry as it exists in the United States today. The three main groups are given in the order of their relative gross business, which in the aggregate amounts to about five billion dollars annually, thus making this combined industry one of the leading ones of the country. Of the various subdivisions, at least nine are recognized as well established and as the leading branches of the industry.

It may seem surprising to those uninitiated in the profession that no greater prominence is given to the electrical engineer in the above analysis. The fact is that most electrical engineers can hardly be classified as constituting, in a business sense, a distinct and separate branch of the industry. Indeed, in common with several other branches of engineering, most electrical engineers are not engaged in general consulting practice but are retained in the special service of the electrical public utilities and manufacturers. Smaller percentages of them are engaged in educational work; in government and municipal service; in the electrical departments of steam railroads, the automobile, steel and other industries; in the designing, estimating and supervisory work of large electrical contractors; and in various other activities.

This preponderance of the electrical engineering talent devoting itself to the service of the central stations, electric railways, telephone, telegraph and manufacturing companies should not be a cause for dismay; rather should it be a cause for gratification, for it has greatly hastened the development of electric service systems and been largely responsible for the great variety of applications of electricity that we enjoy today. To appreciate this

point it may be desirable to make a hurried review of the general trend of business development of the leading branches of the industry.

DEVELOPMENT OF LEADING BRANCHES OF THE INDUSTRY

Aside from the oldest and youngest branches of the industry, all the other leading ones saw their initial development within about a dozen years, 1876 to 1888.

Telegraphy—Telegraphy had its beginnings about 1845, while radio communication is barely over 25 years old. At first all the companies engaged in all but one of the industry branches were small and there was keen competition between them. For instance, there were many competing telegraph companies during the first 20 to 25 years when consolidations began that ultimately resulted in the two large companies that for many decades have handled nearly all the telegraph business of the country. Greater economy and universal service between almost every one of our communities and every part of the civilized world were made possible by this large-scale operation.

Telephony—In telephony control of the basic patents by the Bell system resulted in virtual monopoly until about 1891, when a period of active and later even violent competition began. Extension of telephone service was effected to almost every hamlet and to thousands of farms, but the service was poor, especially from the small exchanges. Hundreds of cities had dual telephone systems, neither of which reached all subscribers. The public gradualy tired of supporting the two services. During the last ten years or so the folly of this competition has been recognized and it has been replaced in nearly all cases by consolidation or co-operation of the competitors, so that with the nationwide Bell system as its backbone there has been achieved universal service, improved quality in the service, and greater operating economy. Within the last seven years marked technical advances were made, these including transcontinental telephony, multiplex telephony, co-operation with telegraph and now even with radio service; the change to automatic or machine switching in the big cities is now also definitely under way.

Central Stations—Soon after the first central stations were put in service in 1882 stations were being built in both large and

small cities throughout the country. Many cities had from two to a dozen or more serving different sections, sometimes two competing actively in the same districts which involved wasteful duplication of distributing lines. At first direct-current service was given with lines limited to a few miles from numerous small and inefficient generating plants. When alternating-current service was developed the lines could be made longer economically and fewer stations of greater size and higher efficiency could meet all requirements. This led to many combinations of the companies and either complete shutdown of the original small plants or their conversion into substations.. The consolidation movement has continued steadily so that there are but few American cities with more than two or three central-station systems serving them and these often are co-operating; very many cities have but one system of importance.

Moreover, the tendency to co-operation has extended even to large districts outside the cities and there are numerous systems interconnected to form power networks covering large parts of some of our states and in some cases several states. For example, with the exception of a few gaps that are to be closed in the near future, there is a continuous network of interconnected high-tension power lines extending along our Pacific Coast states from British Columbia practically to the Mexican border.

Electric Railways—Electric urban railways got their first foothold in 1888. Partly they were electrified horse or cable street-car lines and partly new or competitive lines. The latter were usually built on streets adjoining existing lines without systematic planning to serve the public to the best advantage. Mergers or co-operative agreements have been worked out in many cities to combine numerous small lines into large unified or at least operating systems, in some cases one system serving the entire city. The street railways have in numerous instances been the prey of demagogical politicians and professional agitators, in part due to early errors of management. This, combined with greatly increased operating costs and competition of automobiles in recent years, has retarded the development of these railways and in almost every city presented serious financial difficulties from which the companies are slowly recovering. Interurban electric railways, which received their greatest development between the years 1898 and 1908, have had many of the same difficulties as the urban systems.

Both classes of electric railways have been hit harder in the last five years than any other class of electrical companies. In spite of this they remain the only medium for giving the general public rapid, frequent and fairly comfortable transportation service at low cost, and as soon as the public is taught to recognize this fact by a more reasonable attitude toward the companies the status of the latter is bound to improve.

Manufacturing—In electrical manufacturing competition has always been keen. It was especially so in the early days due to prolonged and bitter patent litigation involving almost every important invention. After many years it became evident that this was benefiting the lawyers more than the electrical interests and then there resulted working agreements for joint use of patents that have had an important effect in stimulating further development of electrical machinery and apparatus. Following lines of evolution similar to those in several other industries, a number of quite large manufacturing organizations have grown up between which there remains wholesome rivalry. There are about 4,000 well established American manufacturers whose products are almost exclusively electrical, so it is evident that the field has not become restricted. The greater resources of the large companies have enabled them to organize extensive research departments which have discovered new scientific principles and applied them to the development of new processes and apparatus. New developments by the smaller companies have been chiefly in the perfection of appliances and accessories.

Radio—Radio communication is getting well under way as a distinct branch of the industry. Radio service to and from ships has long been developed; transoceanic service is more recent, while broadcasting from land stations is the latest development. Several other useful applications of radio are being developed and give great promise for the future to the engineer as well as the amateur, provided the problem of control is satisfactorily solved.

Space does not permit more than casual mention of some other branches of the industry. Jobbing and retailing have little direct interest to the electrical engineer, but they are important functions on which the welfare of at least two other branches (manufacturers and central stations) depends to a considerable degree. Electrical contracting is of interest to the engineer because in

every large installation there is considerable engineering work in the preliminary estimating and in the detailed layout to be followed after a contract is accepted.

RELATION OF INDUSTRY BRANCHES TO EACH OTHER AND TO PUBLIC

A few outstanding facts may be worth noting on the relations of the industry. Each branch of the electrical industry serves the public directly or, in the case of the manufacturers and jobbers, more or less indirectly. With minor exceptions, each branch serves every other. It is this latter service that is drawing the industry together into a more co-operative unit. Formerly there was much more active competition between some of the branches of the industry in undertaking activities foreign to their main functions. For instance, central stations in many cases engaged also in electrical contracting and retailing; contractors engaged in jobbing, etc. The tendency is for each of the branches to recognize the functions of the others and to confine its efforts to its own sphere. This is leading to greater harmony and solidarity, all actively working together for the common good and recognizing that the welfare of each branch promotes the welfare of all.

In serving the public each branch of the industry is brought into intimate contact with nearly all other industries, especially those with important electrical departments. Thus, the central stations supply power to countless other industries; the manufacturers furnish electrical equipment to them; the telephone and telegraph companies serve all of them, as do the electric railways serve their employees. During the recent war this important relation of the electrical companies to the other industries was officially recognized by the Federal Government and the President urged that everything be done to enable these public utilities to render without interruption this service which was proving of such great value to the nation. If this service had not before demonstrated its economy, reliability and general utility it would never have been developed to the high regard which it commands today.

Another important fact about public utility service is that it is now generally conceded to be best rendered as a regulated monopoly. In this way large-scale operation without needless duplication of lines or stations is made possible, large plants of

high efficiency can be built, and the total investment kept to a minimum; this means lowest possible operating costs and fixed charges or, in other words, the lowest price for the service; it also means universal service to all alike without favor or discrimination.

With the exception of electric railways as mentioned above, the position of the electrical utilities in the business world was never stronger than it is today. Quite a few of these companies came through the war and readjustment periods without any increases in their rates—an unheard of record in commerce and industry. The aggregate number of their customers has increased even during the past year of business depression and their aggregate gross income also increased in spite of it. Many of the companies are selling their securities to their customers and employees, thus further strengthening the bond of good will between them.

The welfare of the electrical utility companies is extending to several other branches of the industry with whom they have many business relations, particularly the manufacturers It is also benefiting electrical engineers, of whom a very large number are employed in designing new plants, exchanges, lines, substations and other works, in supervising their construction, in directing their efficient operation in service, and in studying every detail of the system so that better service and greater economy may be attained.

TREND OF IMPORTANT CURRENT DEVELOPMENTS

To show that the field of the electrical engineer is a very promising one it may suffice to cite a few current electrical developments of importance.

Power—During the present year the first 220,000-volt power transmission line is expected to be put into operation in California. Portions of other lines are to have their potentials raised and are to be joined into a continuous 220,000-volt tie line or bus of over 1,000 miles length, which will interconnect several of the large power systems into a superpower network utilizing the water powers of California and adjacent states to the greatest extent possible.

The passage of the Federal Water Power Act in 1920 has stimulated hydroelectric development in many parts of the country; there have been approved by the commission functioning

under this law scores of projects for construction of water-power plants, most of which are merely awaiting improvement in financial condition before starting construction. The general plans of the proposed canalization of the St. Lawrence River rapids, which have been approved by the International Joint Commission and recommended by President Harding, involve the development of hydroelectric power ranging between 1,450,000 and 5,400,000 horsepower, depending on how completely this part of the project is carried out. Studies have been made of the systematic development of the Colorado River for irrigation and hydroelectric power, the latter estimated to amount to 4,350,000 horsepower and to be transmitted in or to seven states.

Last year there was completed under the auspices of the United States Geological Survey an exhaustive survey of the power resources in the industrial region between Boston and Washington. The report urged the existing power utilities to adopt a plan of co-ordinated interconnection into a huge superpower system with full development of all water-power resources and construction of large, efficient steam-electric plants at the coal mines, the power being fed into a common 220,000-volt power trunk or bus with branches to the power-using centers. By 1930 this superpower system would meet the estimated annual requirement of 31 billion kilowatt hours at a saving of $239,000,000 under the cost by the present methods. This report was made by some of the country's foremost engineers, who stated that the plan would permit the electrification of 19,000 miles of railroads with an annual saving to these roads of $81,000,000, besides effecting important power savings for 96,000 manufacturers within the superpower zone.

The need for more power and for greater economy and reliability in its production is also felt in other industrial countries. England, France and Switzerland have had similar superpower studies prepared, with excellent prospects of putting them into effect. Even Russia is said to have plans for superpower production.

Communication—Radical developments are also taking place in the other extreme of electrical practice—that of communication, signaling and the related arts. The transition from manual to automatic telephony is gradually being effected in the largest exchanges; it will involve investment in new equipment aggre-

gating millions of dollars annually for many years, but yield worth-while returns in more economical operation and improved service. An outgrowth from railroad signaling is automatic train control to safeguard against enginemen running past danger signals; the Interstate Commerce Commission is now taking the first steps to have such control installed.

President Harding's Armistice Day address was heard by over 150,000 persons in various parts of the country through the aid of loud-speaking telephones. Radiophone broadcasting is entertaining and instructing thousands of persons daily within receiving range of the transmitting stations. The largest and most powerful radio station yet constructed was recently put in operation on Long Island; when fully completed it will have twelve antennas arranged as radii of a circle three miles in diameter and have a world-wide range. A series of radio stations has been approved by the Army Air Service to permit constant communication with aircraft throughout the country. Experiments in communication with moving trains and with police automobiles have indicated progress in this new and useful field. Multiplexing of telephone lines by "wired-wireless" is being extended. All these developments involve that versatile instrument—the electron tube. The new science of electronics is also finding applications outside the communication field, notably for high-tension rectifiers.

Between the zone of large-scale power production, which now deals with millions of kilowatts, and that of electrical communication, which often involves accurate control of power of the order of a few millionths of a watt, there is a very wide realm of electrical applications of all sorts and all magnitudes touching every activity of life from the cradle to the grave. This article is already too long to permit mention of even a few of these countless opportunities that are presented to the electrical engineer to be of service to his family, his community, his country and to the progress of society in general. These opportunities may be in research, in design, in technical or commercial development, in production or operation, and in management. Electricity has already proven a great boon to humanity and yet its service possibilities are only in their infancy. The rapidity and scope of their further development lies pre-eminently in the hands of the electrical engineer.

THE RECOVERY OF VANADIUM FROM ROSCOELITE ORES

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One of the most interesting and yet baffling problems confronting the metallurgist is the recovery of vanadium from the ores of Southwestern Colorado where one of the two economically important deposits of that metal is found.

Vanadium is one of the most widely distributed metals in the world, traces of it being present in almost all clays, all early primitive eruptive rocks and in the ashes of many plants and coals. In fact no region of the world is known in which the presence of vanadium has not been mentioned. However, with few notable exceptions these occurrences are minute and beyond any hope of economic importance so far as the recovery of the metal is concerned.

The element was first discovered in 1801, but it was thought later that the new metal was only chromium. In 1830 vanadium was rediscovered and its existence proven. It was also proven identical with the metal found in the ores from Mapimi in Mexico in 1801. Inspired by this, Berzelius made a careful investigation of the chemistry of the new element. This was the beginning of our knowledge of the metal, and he did the work so thoroughly that much of our present ideas of it are due to his researches. Dr. Roscoe in 1867-70 added much information and from his results came the first application of the metal in industry. This was in the dyeing industry where it was and still is used as a mordant.

In 1863 a suggestion was made that vanadium might be of value as an addition to iron and steel and its recovery from certain pig irons and slags proposed, but actual application was not made in metallurgy until 1896, when the Firminy Steel works experimented with steel in armor plate. But the real originator of its development was Professor Arnold, whose work at Sheffield, England, and reports are classic. These were published in 1900 and were further augmented and completed by the reports of Sanky and Smith in 1904.

Quite soon after this the discovery of the rich deposits of

Patronite in Peru was made and the exploitation of these deposits resulted in the rapid development of the metallurgy of vanadium.

Previous to the discovery of the Peruvian deposits, the roscoelite deposits along the San Miguel River in San Miguel County, Colorado, had become known through the work of A. B. Franzel and others in the latter part of the last decade of the nineteenth century. Many chemists and metallurgists, especially those of Colorado, had been employed in trying to solve the problem of extracting vanadium from these ores and considerable progress was made in their beneficiation.

The radium bearing carnotite ore deposits in the country immediately west of the San Miguel deposits were made known at about the same time, and at first it was not understood that the two types of ore were different.

The methods of treating the rich ores from Peru are entirely different from the metallurgy of these low grade western ores and for the same reason that the metallurgical treatment of low grade copper ores is different from the early smelting of the rich outcrop oxide and carbonate ores. The Peruvian ore contains the vanadium as a sulphide in a mixture of sulphur and other sulphides, which, after preliminary roasting to remove the bulk of the sulphur, contains more than 20 per cent metallic vanadium and can be treated, therefore, by a direct smelting method. Dr. B. D. Saklatwalla in a recent paper read before the American Electro-Chemical Society (Transaction, Vol. XXXVII, 1920, pp. 347-357) has described the essential steps in this work. The writer was employed by the American Vanadium Company as the private assistant of Dr. Saklatwalla and was associated with him when these processes were worked out. Two methods were in use; one, the direct treatment of the ore without any refinement, and the other, the smelting of the ore first with fluxes for the removal of molybdenum, nickel and other impurities, and the treatment of the resulting slag by the thermic process for the production of ferro-vanadium, which is sold direct to the steel manufacturer. Dr. Saklatwalla briefly sketched the history of the chemistry of vanadium from which some of the above notes have been taken.

The history of the development and treatment of the ores from Colorado is a story of hard work, discouraging results and continued perseverence. There were many early locations and com-

panies formed, but finally a large portion of the properties fell into two large groups, one of which was taken over by the Primos Chemical Company. The process as finally worked out and used in their large mill at Newmire, or "Vanadium" (as it is now called), consisted essentially of the following steps:

A charge consisted of 1500 lbs. of the ore, 90 lbs. of salt and 30 lbs. of practically pure iron sulphide (pyrite) was weighed into a car and run through a Blake crusher. The crusher discharged to a drier, which in turn discharged the ore freed to below one per cent of moisture to a Krupp ball mill 8 feet in diameter. This mill was arranged so that the ore was constantly screened through 30 mesh, the oversize returning to the mill. The finely ground ore was stored in fine ore bins from which it was fed by screw conveyers constantly to either a Wedge or a McDougal mechanical roasting furnace, there being a furnace of each type working side by side.

The roasting furnaces were fired with oil and the heat was carefully controlled by pyrometer couples connected with recording instruments and also with an instrument within the constant sight of the operator. Later it was learned that the ore varied enough so that the operator could decide better from the appearance of the material as it was plowed and furrowed on the hearths whether it was being properly roasted, varying the heat and draft at his discretion, and the pyrometers fell into disuse, except for occasional experimental work. Every hour samples were taken from the hearths and sent to the laboratory where they were quickly submitted to leaching tests in water to determine if the correct solubility of the vanadium was being obtained. These indications gave the real control of the furnaces.

The furnaces discharged continuously into conveyors which carried the ore the length of the building for the purpose of cooling it before it was delivered to the leaching tanks.

The object of the roasting with salt and iron sulphide was for the purpose of forming sodium vanadate, which is readily soluble in water. The use of the iron sulphide was for the purpose of maintaining an even constant temperature throughout the mass of roasting ore. It served no chemical purpose, apparently.

The conveyors discharged the ore into a launder in which was running a stream of hot, weak sodium vanadate solution which carried the ore to the leaching vats. These were large circular iron tanks with flat bottoms fietted with cocoa-mat and canvas

filters. These tanks were about thirty feet in diameter and five or six feet deep. The leaching was done with hot water. Each tank held about one hundred tons of ore and the solution was circulated over and over through it until from tests it carried all of the vanadium it could dissolve when it was drawn off to a sump tank. From here it was pumped to a storage tank for further treatment. It generally carried from 6 to 10 or 12 grams of vanadium per liter or about 12 to 20 or 22 pounds of vanadium per ton of liquor. The weak solution from the tank which resulted from further washing of the ore was allowed to run off to another sump tank from which it was pumped to the launder receiving the ore from the furnaces. This solution was always kept weak, water being added if necessary, so that the vanadium did not rise above 1.5 to 4 grams per liter. By keeping this solution at or near 4 grams per liter the strong solution pumped to mill storage averaged 8 grams per liter or more, which was found to be about the right strength for precipitation of the vanadium, so that the precipitate would carry the least amounts of sulphur and chloride of lime.

The mill storage tanks were of steel. The solution drained from the filling vats was pumped to these tanks by centrifugal pumps where it was cooled. The solution was pumped at the rate of about 50 tons per eight hours, and this rate was kept nearly constant. The vats were leached with hot water from the discharge of the arms of the roasting furnaces where the water was used for cooling the arms and central column. The leaching was done at the rate of about 3 feet per hour. Water was added to the weak solution coming from the leaching vats to make up for the water lost when the wet spent sands were discharged. About 36 hours were needed to leach a vat, and when the effluent solution, tested by adding 5 cc. of sulphuric acid to 25 cc. of the solution and then adding hydrogen peroxide, showed less than 0.10 per cent vanadium when compared with a standard solution similarly treated, the vat was discharged as spent. Hydrogen peroxide will impart a deep cherry red color to an acid solution containing vanadium to the extent of 0.5 grams per 1000 cc., or more, and only a pale straw color when the percentage of vanadium is 0.10 grams per 1000 cc. or less.

The five mill storage tanks were filled in rotation, as it was essential to cool the solution as much as possible or the precipitation would not be complete. When cold the amount of vana-

dium remaining in the solutions would be 0.15 grams or less. When the solution was hot or warm, as much as 0.5 grams or more per liter would remain. The solution was cooled by a jet of air extending down into the center of the tank and discharging the air at the bottom. Each tank held about 60 tons of solution.

Three tanks were used for precipitation, each holding about 50 tons of solution. The usual practice was to have one filling, one in process of precipitation and one discharging. The solution was agitated by air to prevent the precipitate from settling. When a tank had been filled it was precipitated with a solution of iron sulphate, the amount of sulphate needed being calculated by adding from 2.5 to 2.7 lbs. of ferrous sulphate per pound of contained vanadium. In the laboratory and theoretically it requires 2 lbs. of iron sulphate to precipitate one pound of vanadium, but in actual practice it was found to require about 2.5 pounds.

The ordinary method of precipitation was to agitate the solution with air and pump the iron sulphate solution to the center of the tank. These tanks were of steel and had cone-shaped bottoms. The iron sulphate solution was made by dissolving one ton of sulphate in from 2.5 tons to 4 tons of water. Fifty pounds of soda ash was added: After the calculated amount of iron sulphate had been pumped in, the solution was agitated for an hour and a sample was taken. This was filtered and the filtrate tested for iron by acidifying with sulphuric acid and testing on a spot plate with ferri-cyanide solution. The iron should be in decided excess, for it took from 4 to 6 hours to complete a precipitation and a slight excess would have been insufficient. Experience showed that from 0.15 to 0.20 grams of vanadium was still left unprecipitated.

After precipitation the mixture was agitated for not more than 4 to 6 hours to prevent as far as possible the precipitation of any lime. The cementing material in the sandstone in which the vanadium occurs is calcareous, and so the roasting resulted in the formation of some calcium chloride, which went into solution and was present in the vanadium-bearing solutions. The precipitated solution was drawn by gravity to montejus, each set holding fourteen tons of solution and precipitate. Air was turned into these montejus at about 30 to 40 pounds pressure and the solution forced through Kelly presses. It required about one

and a half hours for a cake one-half to three-fourths of an inch thick to form on the filter leaves. This was washed for 30 minutes with water and then discharged into a hopper. The cake was a slimy gelatinous black mud and was carried out of the receiving hopper by a trough and screw conveyor to a Ruggles-Cole drier fired with oil. The discharge from the drier was granular and brown in color and was shipped to the refinery at Primos near Philadelphia.

Here this "oxide" was mixed with grained aluminum and the proper amount of iron turnings or hammer scale and reduced by the thermic reaction to ferro-vanadium, which was sold to the steel industry for the same purpose as the product of the American Vanadium Company.

The process as outlined above was the product of many years of research and represented the contributions of several chemists. It left much to be desired. The actual recovery, it was estimated, was very low, being hardly more than 60 per cent of that actually contained in the ore in the iron vanadate and the refinery only recovered some 90 per cent of this in the ferro-vanadium. Thus only between 50 and 60 per cent of the vanadium in the low grade ore was actually recovered and sold. The company was very fortunate in having a large deposit of ore, a bed several hundred feet in extent in both directions and some 15 to 20 feet thick. From this deposit they were able to take over 100 tons a day for two or three years steadily. It seemed that the deposit would prove practically inexhaustible and that it would continue back under the mesa land indefinitely. Large acreages of this prospective vanadium bearing land were purchased and prospecting on a large scale started. They soon encountered a vertical fault which threw the continuation of the ore beds to a lower level.. Nothing daunted they sank a deep shaft and after pumping tremendous quantities of water for many months finally succeeded in reaching the continuation of the strata only to find them not entirely barren, but poor in grade and small in quantity. Other areas, however, proved productive and the company was able to continue operations.

The owners of the other large group of claims had spent the time in perfecting the title to their ground and consolidating their holdings, but doing little actual development work. Stimulated by the high prices of the war period and great demand for vanadium which could not be met even by the great capacity of

the American Vanadium Company treating the Peruvian ores, the owners of this ground decided to commence development work and undertake the production of vanadium. The writer was employed for the purpose of undertaking the metallurgical treatment of the ores. These people had had chemists in their employ conducting research work and patented many valuable processes for the treatment of their ores. These processes were based upon different principles from those of the process just outlined as practiced by the Primos Chemical Company, and it was thought that a process could be developed that would give greater recoveries and at the same time make a higher grade product without in the least interfering or infringing on the patented features of the process in use at the Newmire plant.

When in the employment of the American Vanadium Company the writer conducted many experiments in the laboratory and on plant-scale in the metallurgy of vanadium. In fact, it was felt that practically nothing was known of the treatment of such ores and an attempt was made to review the entire field of ferrous and non-ferrous metallurgy as then known for the purpose of applying such principles to the beneficiation of vanadium ores. At one time or another use was made of almost all conceivable reagents and apparatus in these experiments. Expense and cost of experimental apparatus was a secondary consideration. Of course the greater part of this work was done for the purpose of treating the patronite ores of Peru, which are the source of the vanadium produced by the "Vanadium Corporation of America," as the compony is now styled.

The method finally adopted for treating these ores was that of fusing it with soda ash, with or without other additions, thereby separating out the nickel and other sulphides in a matte and forming a slag which was largely sodium vanadate. This reversed the usual process, whereby the slag is the waste product and the matte the valuable portion. We stored the matte until some future time and treated the slag, by granulating it, mixing it with grained aluminum, hammer scale, steel turnings and some fluxing materials and the thermit process of reduction was carried out in large furnaces. These were practically large pots, 9 feet 3 inches high, and 4 feet 6 inches in the clear. They were lined with magnesite and heated with large gas glowpipes before the reduction operation was started. The aluminum oxide formed in the reaction united with the soda and other impurities forming

a slag that was tapped off from time to time as it formed and the alloy allowed to fill the furnace up to the top. Attempts were made at first to tap this alloy into moulds, then into ladles, but the contact with the air and the consequent oxidation of the vanadium at such a high temperature proved wasteful, and it was found better practice to allow the alloy to accumulate in the furnaces. When full, the furnace was allowed to cool, the steel shell removed and the "button" weighing some 20,000 pounds stripped of the magnesite and then broken up by placing it on a large "plate" (a large block of concrete reinforced and covered with steel plates) and allowing a "skull crusher" to fall upon it. The pieces were rough crushed then in a gyratory crusher, the product of the crusher being screened to different sizes and packed into small kegs for sale. Different customers used to specify the grade of fineness to which they wished the alloy crushed, some wanting it coarse and others fine.

The slag from the furnace was crushed, ground and concentrated on Wilfley tables, a large percentage of fine entrained alloy being thus set free and recovered. But even with this recovery the remaining fine slag or "tailings carried from 2 to 4 per cent vanadium, and really was a richer vanadium "ore" than the average of the roscoelite ore of the San Miguel country. Upon investigation we found that we could regrind this slag, mix it with soda ash and salt and roast it, then leach it with water, recovering a large part of the vanadium remaining therein. The old slag piles became quite a source of profit to the American Vanadium Company during the last days of the wear.

It occurred to the writer that these fused and highly refractory aluminum slags should not be more difficult to treat than the low grade ores of western Colorado and that roasting with a mixture of soda ash and salt would, perhaps, yield a larger proportion of the contained vanadium as sodium vanadate. Also in the course of some other experimental work the exact conditions for precipitating from alkaline solutions the whole of the vanadium as vanadic acid by means of sulphuric acid on large scale operations had been determined. Hence we could produce a high grade fused vanadium oxide in place of the low grade ferrous vanadate and recover more of the vanadium in the ores. A preliminary outline of the process as it would work in practice was drawn up somewhat as follows:

Crushing—The crushing plant was to consist of a rock breaker,

possibly a gyratory crusher followed by rolls and a ball mill. Probably would have to introduce some kind of a drier. It had been the experience of the Primos Company that the ore must be dried before crushing in a ball mill. Also the salt and soda ash of commerce are not dry and must be dried. The ore naturally contained from three to five per cent of moisture. It is well known that ball mills will crush efficiently dry or wet and it is also well known that they can not be operated on damp material. There must be either a perfectly dry mix or a stream of water, and there is no middle road.

Roasting Plant—The essential part of this department to consist either of a Wedge or Herrshoff furnace, or perhaps a simple McDougall furnace. The object of this operation was to form sodium vanadate by the use of sodium carbonate or soda waste and salt in place of salt and pyrite, as was the practice at the Primos Company. The furnace to be so arranged for external firing with either crude oil or producer gas that we could control the temperature and atmosphere of the furnace.

Leaching—The product of the roasting furnace after cooling below 300 degrees C. was to be delivered not to a leaching tank but to the first of a series of agitators similar in principle to the Dorr agitators or Pachucca tanks. The leaching to be performed in the agitators with hot water and steam. There were to be a series of three or more of these agitators, the ore passing from one to the next, and so on, the plant to be of such capacity that it would take the ore three or four hours to pass through the agitators. The discharge from the last was to be received upon a sand filter; the sands after proper washing to be discharged to the dump. These sand filters are so arranged that two solutions may be taken from them, the strong solution being first removed and then the sands sprayed and washed with water on a traveling bed and this water removed, leaving the sands washed free of contained soluble vanadium. The washed water thus supplied became weak vanadium solution, which was to be used to meet the fresh ore as it was charged into the agitators.

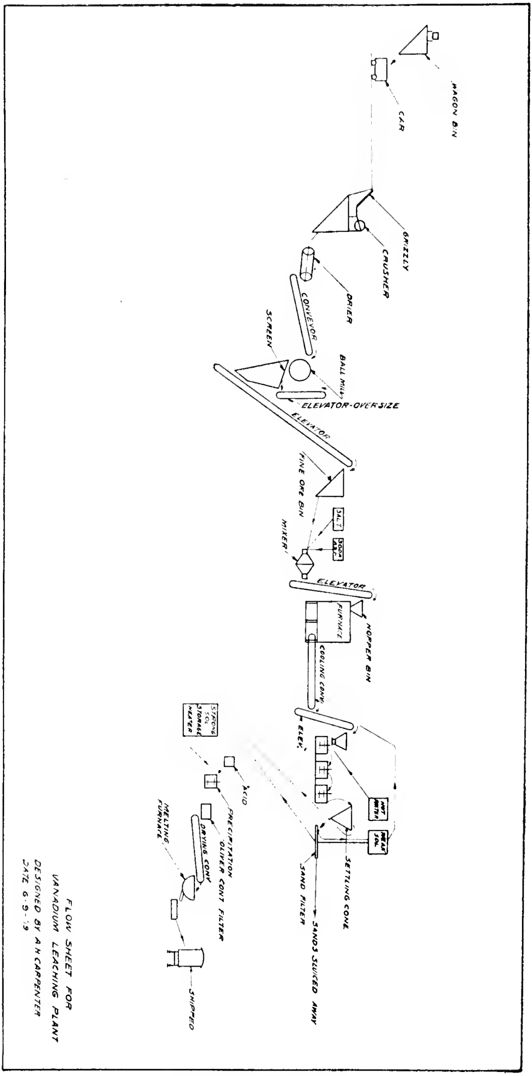
Precipitation—It was proposed to use sulphuric acid. In the laboratory this precipitation cannot usually be made to completion on a small scale except under carefully arranged conditions, but upon a large scale using big tanks and taking advantage of the "mass reactions" it can be made so complete that 99½ per

cent of the contained vanadium is easily recovered in the precipitate. The solution was to be then filtered upon an Oliver drum continuous suction filter. The precipitation was to be made in acid resisting Dorr agitator tanks, which were to discharge directly to the Oliver filter. The filter cake from the drum filter was to go continuously to an automatic drier and the filtrate, which would show only a trace of vanadium with acid and hydrogen peroxide, would go to waste.

Having decided to build the plant, the company asked to have it designed, making use as far as possible of an old gold stamp mill which stood upon a portion of their property. This we tried to dissuade them from doing, as, in the opinion of the engineers, they would be much better off to scrap the old mill entirely and build everything new. In this they, unfortunately, overruled us, and we had to do the best we could. The old mill had been once made over to add a cyanide department and it was certain that the attempt to use it was far more costly than it would have been to restroy it completely. Herewith is reproduced a "flow sheet" as it was proposed to send the ore through the mill.

From the day it started the mill was a success metallurgically, a little vanadium oxide being made within a few hours of the starting of the furnace. We, of course, encountered difficulties in starting new machinery, but far less than usual, and in a couple of weeks everything was running smoothly.

As finally completed the mill consisted of the old crusher of the stamp mill relined and rebabbitted, a crushed ore bin, to the gates of which were attached automatic feeding devices. A large salt bin was built which could discharge its salt automatically to the ore conveyor which fed the drier, so that the fine ore bin was always kept full of finely ground dried mixture of ore and salt. About ten per cent of salt and soda ash per ton of ore was used. From this bin the ore was discharged by automatic feeding devices to the boot of an elevator which fed the furnace, an old McDougall furnace which had been the property of the old Mampa plant near Salt Lake City changed and refitted for our purposes. As originally designed this furnace was used for the purpose of roasting copper sulphide ores by means of their own heat of combustion.. We altered it for our own purposes by cutting holes through the sheets and brickwork for the introduction of oil jets and for the couples of the pyrometer. We had also to change the manner of discharge.



Flow Sheet of Plant.

The discharge of the furnace was received in a trough in which was a screw conveyor, and into this we led the returning weak solution for the purpose of commencing the leaching operations. This discharged into the boot of an elevator which fed the first of the agitators. There were three of these, 8 feet in diameter, of the Dorr type. These gave some trouble at first by becoming stopped up at the least irregularity of feeding. We found that the sand of our work was not well adapted to these machines as designed, but we designed and placed near the discharge of these, small sand tables which allowed us to control the discharge of the sand in proportion as it was received and with this addition the agitators never again gave any trouble of this kind. These machines have to be carefully watched, for if any foreign substance accidentally falls into them it will almost surely cause a stoppage.

The agitators discharge to an elevator which discharged the sand and solution to a settling cone, the overflow of which ran either to the precipitation storage tanks to the evaporator tanks, or was returned to the circulation, depending upon circumstances, while the thickened sands fed the sand filter. We found the introduction of this cone settling device essential to the proper control of the sand filter and gave a better washing of the sands.

The principal departure from the practice as first outlined was the substitution of acid sodium sulphate for sulphuric acid as a precipitant for the vanadic acid with the consequent result that we could precipitate much lower grade solutions than with the sulphuric acid. As it was necessary to partially evaporate large tonnages of solution to get the proper condition for successful sulphuric acid precipitation, this resulted in a great saving in cost of operation. The advantage of having the sulphuric acid in a solid condition seemed to be important.

The oxide from the Lowden drier was discharged into a cast iron pot and the oxide fused down and cast into pigs. This was weighed, packed and shipped to Niagara Falls for reduction to ferrovanadium in electric furnaces, which was different from former practice of reduction, by using grained aluminum and the thermic reaction.

The operations of the company have been suspended during the business depression, but, doubtless, will resume operations at a more promising time.

THE ENGINEER AND THE WORLD'S FUTURE

H. R. WING, '22 *

It is altogether appropriate, in making predictions, to delve somewhat into the past. Let us review, therefore, the characteristic periods of the Western Civilization, as we know them. What are the "high spots," as it were, of the Western Civilization that are indicative of the propensity of each characteristic period?

Without going too far back, the first of such periods was perhaps the Grecian Period. This period was characterized by its philosophical reasonings. The Greeks then tried to philosophize everything. Close to this was the Roman Period, the tendency of which was world domination. The next period was the Renaissance, which had its indulgence in the revival of classical learning and art. After this the period of Religious Freedom asserted itself and resulted in the pioneer establishment of the American colony. Then came the Revolution of Governments, of which the climax was the French Revolution.

This in brief is a picture of the past progress. In it is found the voice of the people for philosophy, religious freedom, etc. What then are the tendencies of the present period? I do not think we are indulgent in philosophy, nor are we too indulgent in religious freedom. Bolsheviki government does not pay; therefore our present form of government is efficient enough. What then are the problems of the world today and what are they to be in the future? Moreover, what are they to the engineer?

Let us review the achievements of recent times. Within a half century we have seen the perfection of the steamship, the steam engine. the telephone, the aeroplane, and the turbo-generator. We have seen a remarkable history of inventions. We are making that history now.

Together with the above achievements we hear also these expressions in common usage, such as "Humanity," "Make Safe for Democracy," "Capital and Labor," "Efficiency," and "Economy and Service."

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*Prepared as an initiation requirement of Tau Beta Pi.

Now from such achievements and expressions as these, what does an average man conclude about the present tendencies of the world? What does any man conclude? Particularly what does an engineer conclude?

Let me attempt to draw that conclusion for the engineer. We are living in an age of *Economy* and *Service*. Everything is analyzed as to its economical and serviceable attribute to the world and to its existence. We even analyze the cold facts of humanity with that point of view. We are sifting the non-essentials out from everything leaving behind only the necessities. This is the reason for so many inventions. In engineering we ask ourselves whether such a project is economical or not. What was the "Limitation of Armament Conference," but a question of economy? It was to find out whether in the long run it would be more beneficial to a nation to build large battleships and waste money that way or to use that money for some other purpose, such as building transcontinental highways over both land and water.

So it is with this world's future. The world's future will be a problem of economics. Only an economical world will exist. You may talk of idealism, morality, and humanity. But the cold facts are economical ones. Upon these depends the world's future.

What now of the serviceable world? A world of service is a world of satisfaction. A human want, both physical and intellectual, is a want of satisfaction. This is closely related to economics. Man must live, and in order to do so his wants must be satisfied. Of course he may be left to follow the Darwinian principles of "struggle for existence" and "survival of the fittest," and then finds himself in the midst of plenty by elimination of his other fellow men. But notwithstanding this, the law for the increase of population and subsistence—namely, population increases in a geometrical proportion and subsistence increases in an arithmetical proportion—as formulated by Thomas Robert Malthus in his "Essay on the Principle of Population," 1798, still holds and more than offsets the Darwinian principles. This fact is verified by the recent World War. The population of the world was somewhat reduced. But we are still confronting the question of economics in society, in fact more so now than ever before, because we find millions of people starving in Europe.

Taken all in all, the present situation of the world is one of

economy. And I will not hesitate to state that the tendency of the world's future is one along the same line. This conclusion seems more and more logical every day; for, do we not hear appeals for food from all over the world today?

Now then, in order to serve the world in the future with economical wants, we must have industries. Industries require engineering, and engineering needs engineers. Therefore the engineer, then, is the man of the future. On him depends the supsistence and therefore the existence of the world. We have one such engineer holding a cabinet position today. Not only will the engineer serve the world with economic wants, but he will also lead the world in economic lines. He will harness the power of the sun and water with turbo-generators. With this he will pry open Nature's innermost treasures of luxury and her archives of secret laws. Then he will control the powerful elements of the air by aviation. He will control the production and reproduction of natural products by chemical research. He will command the course of streams and help Nature herself to beautify this earth by irrigation. He will shorten the barriers between the communities of this world by electrical communication and transmission. In short, he will make this world a better and more beautiful place for humanity to live in.

Behold, then, the engineer, the man of today and the man of the future and the man of all times.

THE BEAUX ARTS INSTITUTE OF DESIGN COMPETITION

The Architectural Department is now in the second year of its registration with the Beaux Arts Institute of Design, a national institution, with which the principal architectural schools of the country are associated. Almost all of the Senior problems are issued by the Institute at New York, and when finished are sent there for judgment along with those from the other colleges. The Armour men have shown themselves able to hold their own in open competition. Some of the honors won this year follow:

F. W. Cauley—2nd medal—A Naval Pantheon.

H. K. Beig—2nd medal—A Naval Pantheon. H. K. BIEG

T. M. Hofmeester—3rd medal, highest award—Twelve hour sketch—A Cenotaph.

R. J. Nedved—$25 prize—Warren Prize Competition—A Hotel Establishment.

The last Senior problem of the first semester was something new, a prize problem, in which one hundred dollars was offered by Mr. C. Y. Everson for the best design for a lighting fixture for a bank. This prize was won by O. F. Cerny.

STANDARD OF LIFE

The life that the majority of people now live will probably constitute the standard of life in the perfect society. What most folks have found good and worthy, no future system is likely to upset. When the blind guides of social discontent announce that the majority are "doomed to live common lives," they do not see the uncommonness of our common life, nor does he see that the so-called common life is far and away the best life of all. It will need a little more room, a little more leisure, a little more sense of security, but in all it is the type of life the majority of the people are going to choose when the social millennium permits every man to make a choice. The common life and character constitute the golden age.—Selected.

The Armour Engineer

The Quarterly Technical Publication of the

Armour Institute of Technology

VOLUME XIII. MARCH, 1922 Number 3

Published four times a year, in November, January, March and May. Publication Office: Federal and 33rd Streets, Chicago.

TERMS OF SUBSCRIPTION.

The Armour Engineer, four issues, postage prepaid, $1.50 per annum
Single copies, 45 cents.

THE NEW COVER DESIGN

Comments from readers of the "ENGINEER" on the new cover design are indeed gratifying. It is an indication that the feeling on the part of the staff of the need of such a new cover was justified. However, it is only a step in the necessary improvement of the "ENGINEER" and additional criticisms are desired and will be appreciated.

The design of the cover was made by W. J. McCormack, senior student in the department of Architecture.

"SAFETY ENGINEERING"

During the past decade there has been a great development along the "human side" of industry. One of the most successful and most worthy features of this development is the so-called "Safety First" movement. Today, we have a national organization with branches in many of the larger cities, devoted exclusively

to furthering the interests of safety in industry. The National Safety Council carries out its program of publicity through its own monthly publication and through its affiliation with the local Chambers of Commerce in the large industrial centers.

Why has so much importance been placed upon industrial safety in these days of modern dividend competition? As a matter of fact are not these two intimately related in such a way that the success of one depends upon the other? The local street railway company is certainly very much interested in reducing their annual budget covering accident claims. The phenomenal success of the modern safety movement is due to the fact that it usually pays big dividends in cold hard cash.

The engineer is interested in safety, chiefly in the design of engineering structures. Modern skyscraper construction is largely a problem of safety in design and in many other lines of work the engineer must always consider a given design from the standpoint of safety. The railroads are required to install modern safety appliances in conformity with the rules and regulations of the Interstate Commerce Commission. Just recently an I. C. C. order has been issued compelling the installation of automatic train control in some form acceptable to the commission. The engineer carries a heavy responsibility in designing modern railway safety appliances.

The elimination of fire hazards is also a subject of interest to the "safety engineer." Engineers have played an important part in the standardization work of the Underwriters Laboratories. In this connection Armour Institute of Technology has performed a creditable service in the establishment of a course in Fire Protection Engineering.

In the operating field the modern safety movement has been instrumental in the formation of the new position of "safety supervisor." Many large industrial and public utility corporations employ one or more technically trained men to look after the mutual safety interests of the company and its employees. A central safety bureau has been established in Chicago to carry on the "safety first" crusade among all the affiliated public service corporations of this district.

Present indications seem to point the way to even greater accomplishments in the future by trained engineers in the field of accident and fire prevention. The engineer is certainly the most logical man to "fill the bill."

THE PLACE OF SPIRIT IN EDUCATION

Huxley defines education as the "instruction of the intellect in the laws of Nature, the fashioning of the affections and of the will into an earnest desire to move in harmony with those laws." Harmony with the laws of Nature! What does this mean? What are her laws? The first law of Nature is to exist, to live, to breathe, *spirate*, to have spirt. Where then in Huxley's scheme for education is the lifeless, spiritless, dried-up student of the cartoon? Where is Chaucer's clerk of Oxford who "noght o word spak (he) more than was nede"? Where is the haggard, underfed professor, "severe and stern to view"? Certainly not found in the modern American college are these, nor concerned with an education which moves in harmony with the laws of Nature and which attracts the men of our age.

Since the chief aim of Nature"s law is to produce a well rounded individual, an education in accordance with them must involve the development of spirit as well as of intellect and of physique. And what is spirit? It is the breath of life, the very essence of being. It results in energy, ardor, enthusiasm, power; it affords courage, animation, vigor, vivacity. It is the life-giving principle, the source of inspiration, the spring of enterprise. The mind may reason, draw conclusions, and determine upon a line of procedure; the body may perform its duties promptly and exactly in obedience to its master; but it is the spirit which attains results with full measure of satisfaction and usefulness. Let a mind, capable of the greatest precision and of the deepest intellectual pursuits, work out a plan of action in which no flaw can be found; let a body, well developed through years of physical training such as can but produce a perfect specimen of human being, assume the accomplishment of the task set for it; but let the spirit which shall animate the achievement and insure energy and vitality to its fulfilment be lacking, nad we have a dead thing before us, full of potentiality but impossible of attainment.

In the school these functions of the individual are found in similar positions of importance. The mind is there and needs no urging. Alas, too often the intellectual pursuits are given such precedence that the result is a contorted view of life on the part of the faculty as well as of the students. The body is there, ready to perform the dictates of the mind. A great mass of physical energy is waiting, almost dormant, for the awakening that shall

convert it into a splendid, potent force. It is for the spirit that both are waiting that the body may fulfill the mandates of the mind with buoyancy, eagerness, and enthusiasm. Spirit is the organized and directed energy, the unified purpose, the driving power of the school. Without it the school is a lifeless, listless, unorganized mass of individuals each striving for his own personal gain, oblivious of the needs and interests of his fellow workers. With it this mass of individuals becomes a unified power, dominated by singleness of purpose, allegiance to the institution, and regard for its welfare. Of course the school must give heed to the developing of the body; it must dedicate its best brain power to the training of the mind; but it must focus its keenest efforts upon the installing of spirit.

Not only must spirit be created; it must be transfused. There is no difficulty in finding spirit scattered here and there among some few members of any group. It would be phenomenal to find a number of wide awake men, absorbed with the task of preparing themselves for their places in the world among whom there were no leaders with power. The goal which these men must set is that the group shall contain no member who lacks this fire of enthusiasm, whose heart fails to throb with passion over the success of his mates, whose soul is not lighted with a bright fervor as he contemplates the victories of his school. And that faith in the honor of his clan, that glory in the success of his own group is as old as time,—as deep rooted as eternity. Ever since tribe fought for brothers in the tribe, clan for fellow clansmen, has man spontaneously leapt to the defense of brother, and dared all for him. So should the spirit of the clan permeate the school. For Alma Mater! That shall be the battle cry to carry us into every field. Whether in the quiet hours of study, in the competitive work of class room, or in the exciting rivalry of athletic field. that force of life, that vital energy, that PEP should permeate our every thought and action so that the four years of college life may be imbued with the greatest principle dominating our lives—spirit. Then into this world shall we carry an indefatigable ally, an irresistible power before which all obstacles shall become as nought. Then shall our Alma Mater forge ahead into a glorious future, swept along by the inevitable fervor of her sons.

H. M.

ENGINEERING SOCIETIES

REPORT OF A. S. M. E. MEETING

The last regular meeting of the Armour Student Branch of the A. S. M. E. was held on Friday, February 17, at 10:30 a. m.

Mr. Bradbury announced an invitation from the Parent Organization to have three students talk at the joint meeting of the A. S. M. E. and the Western Society of Engineers at the Engineers' Club, Monday evening, February 20.

Mr. Bradbury then made appointments for speakers at this meeting as follows: E. G. Walker to give an outline of the paper prepared for the national convention in New York last December entitled the Armour Idea of the Student Branch; and P. J. Rupprecht to talk on what an Armour man does in his Senior year.

These appointments were ratified by the Society.

Speakers for the meeting were then called upon. Mr. Graicunas gave an interesting talk on the scope and activities of the future engineer. Mr. Rumley was then called upon for a short talk and agreed to speak in order "to obtain practice," as he termed it.

The joint meeting of the A. S. M. E. and W. S. E. at the Engineers' Club Monday, February 20, was a success. The dinner was called at 6:30 p. m. and after dinner the chairman of the meeting, Mr. Lofts, introduced Mr. Bradbury, who expressed the appreciation of the Student Branch to the Parent Organization for inviting the speakers to the meeting. Mr. Bradbury then introduced the three Armour men who were to speak. The men were allowed eight minutes apiece.

Mr. Rupprecht was accorded the greatest amount of applause and it was well deserved as his talk was particularly well given.

The meeting was then adjourned to the rooms above where an illustrated lecture was given by Mr. Boehme of the Chicago Mill and Lumber Company on the manufacture of paperboard for box making. The lecture very interestingly described the manufacture of this new style of packing box from its origin as waste paper obtained as refuse from office buildings to the finished product.

It is hoped that the Parent Organization will continue to give our Student Branch the opportunity to have our men give short

talks at their meetings. It is true that a great deal of benefit is derived from speaking at our local meetings, but the experience derived from speaking at these larger meetings before prominent engineers is of a decidedly greater benefit.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

As in the past, the local branch of the A. I. E. E. has been successfully following the plan suggested by Professor Snow of having the student members speak at the local meetings, rather than call in prominent graduate engineers to address the men. This plan allows the members of the A. I. E. E. to secure the greatest benefits from the meetings because it supplements the transfer of technical knowledge with valuable self-training in public speaking.

The first meeting of the second semester was held on February 17th, in the Electrical Lecture Room. At this meeting the men were treated to a very interesting talk on the subject of "Automatic Telephony" by Mr. H. G. Love. He amplified his subject and explanations with a complete working demonstration of the apparatus as manufactured by the Automatic Electric Company. The automatic switching equipment was connected up with two subscribers' stations, which enabled the speaker to easily demonstrate the talking and ringing circuits. Although the particular equipment described by Mr. H. G. Love is not the exact type which is being installed by the Bell companies in the large cities in the country, the subject is nevertheless of interest to everyone, as the manual switchboards in Chicago will some day be changed over to the automatic type.

At the last meeting a committee was appointed to consider the possibilities of an A. I. E. E. banquet and inspection trip through one of the recently constructed motion picture houses. Such an inspection trip would undoubtedly reveal some of the secrets of stage lighting which play an important part in the modern theater.

All electricals should watch carefully for future "doings" of the A. I. E. E.

Lester E. Grube, Secretary.

WESTERN SOCIETY OF ENGINEERS

At the last meeting of the W. S. E. the organization had the pleasure of being addressed by Mr. W. J. Martin, of the Barrett Company. He gave an illustrated lecture on the use of refined oil in the construction and maintenance of highways.

The following is extracted from the Code of Ethics of the Western Society of Engineers:

THE ENGINEERING PROFESSION

Engineering is a useful art. Its purpose is to constantly promote a higher civilization for mankind by discovering and creating improvements that are in harmony with natural laws.

The engineer, while at times a scientific discoverer, is more commonly a student and interpreter of science. His chief function is to reduce scientific discovery to practical, useful and economic forms for the safety, comfort and convenience of mankind.

Pure science concerns itself with the discovery of the laws of Nature. The engineer ordinarily adapts the discovered laws to the use of man.

While engineering in its elementary operations utilizes mechanical and mathematical methods of expression, which, at times, gives such work an undue appearance of exactness, these aids properly understood are, nevertheless, entirely tools subordinate to the chief function of the engineering mind which is essentially judicial and reasoning in character.

The engineer, properly analyzing his problem, secures and arrays the facts and develops the evidence affecting the results in each case, tests them in the light of reason and natural law, and judicially determines from the record before him, the proper economic procedure. In all his work to some extent, and in his higher responsibility to a very large extent, he is the final judge who is versed in the science of applying economic truth and natural law so as to conserve mankind.

Engineering, therefore, being a vocation in life requiring specialized intellectual attainment in the domain of judicial, economic and scientific inquiry and practice, is a profession, and is subject to all the opportunities and restrictions heretofore recited and commonly found to be needful to professional life.

E. M. Seaberg, Sec'y.

ARMOUR CHEMICAL ENGINEERING SOCIETY

The abandonment of theses in all departments has brought about a revision in the laboratory work in industrial chemistry in the department of Chemical Engineering.

Senior students in this department have been accustomed to spending their laboratory periods during the second semester in the preparation of their thesis.

This work has now changed and a rather extensive series of experiments has been planned embodying many of the typical processes as carried out in the chemical industries.

Each group of students is expected to carry through eighteen preparations. In some instances the students are permitted to select which experiment from a certain group they will perform. In every case where the experiments are fundamental, either from the process used or the product obtained, all the students in the class are required to carry through the same experiment.

The foreman of each group prepares a preliminary statement which is presented to the professor in charge, outlining the materials he expects to use, chemistry of the process, and the procedure necessary to carry through the experiment. This preliminary must be accepted before the work can proceed.

The final report is submitted at the completion of each experiment which covers in detail the work as it has been done with the results obtained, discussion of the process as carried through.

The list of experiments includes such work as manufacture of paper pulp, preparation of a boiled grained soap, making of sugar from sugar cane, preparation of chemically pure acids from echnical acids of similar concentrations.

Some of the processes used in the experimental work can be found well outlined in the literature, other processes are yet somewhat in the experimental stage and complete descriptions cannot be found in the literature, in these instances the student is expected to use his own ingenuity in constructing, the procedure which should bring satisfactory results. Some experiments of this character are: the preparation of potassium sulphate from alunite, preparation of aluminum nitride and the preparation of potassium permanganate.

The foreman of the group when the final report has been pre-

sented and accepted, then reads this report to all the members of the class for comment and discussion.

It is believed that this kind of work will give the students a good working knowledge of the equipment used industrially in the preparation of various classes of chemicals, and will accustom them in taking such data on chemical processes as will enable costs to be computed. This work is deemed to be of a much more practical value than the customary laboratory work which has in the past been connected in the preparation of a thesis.

J. Warren McCaffrey.

BE WORTHY OF IT

I may not reach the heights I seek,
My untried strength may fail me;
Or, half-way up the mountain peak
Fierce tempests may assail me;
But though my goal I never see
This thought shall always dwell with me—
I will be worthy of it.

I may not triumph in success,
Despite my earnest labor;
I may not grasp results that bless
The efforts of my neighbor.
But though life's dearest joy I miss
There lies a nameless strength in this—
I will be worthy of it.

—Ella Wheeler Wilcox.

COLLEGE NOTES

ASSEMBLIES

At our fifth assembly of the school year we had the honor and pleasure of listening to a talk by Mr. Charles H. MacDowell, President of the Western Society of Engineers and associated with the Armour Fertilizer Works.

Mr. MacDowell gave us a heart to heart talk from his personal experience and especially emphasized a fault in college men as he had found them. He said that the average young college man is perfectly willing to give his judgment as to a certain line of action, but is in most cases lacking in the *"follow through"* necessary to see it carried to a satisfactory conclusion. The closing part of his speech follows:

"The call for technically educated men, both in the manufacturing and executive departments, is constantly increasing as their value is better understood and appreciated. Modern business is becoming more and more an engineering proposition. The technical student of today will have many opportunities for work, for service, and for success. He, on his part, must round out his personality; must endeavor to become increasingly hard-headed without becoming bone-headed; he must be tolerant; he must prepare himself to be a good mixer and make himself understood and appreciated by other than scientific men; he must not underrate these men because they have not been tchnically educated, as they may possess certain abilities he is shy of; he must study co-operation and be prepared to do team work with his colleagues; he must appreciate the fact that the ability to make money in a large way is not possessed by all people, but that industry, thrift, character, courage, decision and good judgment will permit him to secure just compensation for his services and a competence for the days to come; he must understand that money received is not the only equivalent for work—that satisfaction from successful service in developing new and better ways for accomplishing important results is after all the highest type of compensation; he must realize that, by the elimination of jealousy and by using his monkey wrench, if he possesses one, as a constructive tool, he will so alloy his services and his personality with his colleagues that success will naturally come to him."

At the eighth assembly of the year, held Tuesday, February 21, we were addressed by the Rev. Dr. R. A. White on the subject, "The Making of a Nation." The talk was excellently illustrated by lantern slides. Many interesting scenes from the life of Washington and from Revolutonary Days were shown. Dr. White had during the same week completed the thirtieth year of his pastorate at the People's Church of Englewood.

The ninth assembly was a pep meeting. During this semester the hour between 10:30 and 11:30 has been kept open for all students, thus giving an hour in which assemblies and other meetings may be held without interference with recitations. At this assembly not over 50 per cent of the student body was present, illustrating the wrong attitude taken by a good many of the students toward the assemblies and the lack of spirited interest in school activities on their part. The main purpose of the meeting was to boost the song and cheer contest, described elsewhere.

CHARLES TOUSLEY MALCOLMSON

Charles Tousley Malcolmson, 522 Belmont Avenue, Chicago, formerly of St. Louis, Mo., died suddenly at the Grant Hospital of Chicago on January 10, 1922, after a brief illness. He was buried at Bellefontaine Cemetery, St. Louis, Mo., on January 12.

He was a graduate of Armour Institute of Technology, Class of '97. In 1899 he became chief engineer of the United States Commission at the Paris Exposition. In 1901 he was chief engineer of the South Carolina and Interstate World's Industrial Exposition and in 1902 he was superintendent of machinery at the St. Louis Exposition. He then returned to strictly industrial work, becoming general superintendent of the Lanyan Zinc Co. of Iola, Kansas, where he remained until 1905. In the latter year he assumed charge of the coal testing plant of the United States Geological Survey (Briquet Division) and continued in that capacity with enlarged responsibilities when the plant was transferred to Norfolk. In 1908 Mr. Malcolmson built the briquet plant for the Rock Island Coal Co. at Hartshorne, and continued in charge of its operation. Then he accepted a position as briquetting engineer of Roberts &Schaefer Co. of Chicago and remained with this firm until he organized, in 1912, the Malcolmson Briquet Engineering Co., which later consolidated with the St. Louis Briquette Machine Co. under the corporate name of Malcolmson Engineering & Machine Corp., of which he was president.

Mr. Malcolmson was an acknowledged authority on briquetting plants, and it was during his latest years that his best work was done. The following successful coal briquetting plants were constructed under his supervision ,and stand as a memorial to him: Standard Briquette Fuel Co., Kansas City, Mo.; Berwind Fuel Co., Superior, Wis.; Pacific Coast Coal Co., Seattle, Wash.; Virginia Navigation Coal Co., Norfolk, Va.; Fuel Briquet Co., Trenton, N. J.. Mr. Malcolmson was closely connected with the development of a process for the low-temperature distillation of coal, and in 1920 a briquet plant and retort equipment was furnished for the Clinchfield Carbocoal Corporation, South Clinchfield, Va., which is now turning out a product called carbocoal. During recent years he also was very active in adapting peat to fuel requirements, and in 1921 a peat harvesting system was installed for the Peat Committee of the Canadian Government.

He was a member of the University and City clubs of Chicago and the Lawyers Club of New York; also American Institute of Mining Engineers, American Peat Society and International Railway Fuel Association.

ADDITIONS TO THE ELECTRICAL ENGINEERING LABORATORIES

Quite a number of additions have been made to the equipment of the Electrical Engineering Laboratories during the present school year. Some of these have been in the nature of replacements, others to extend our facilities in lines which have already been partly provided for and still others to provide more recent applications which have not been previously represented with us.

Two direct-current generators of interpole design increase the number of units available for direct current machinery experiments. Likewise two 10 h. p. induction motors increase the number of alternating current machines available. A 5 h. p. repulsion induction motor has also been added to our equipment.

A number of ammeters, voltmeters, wattmeters, and frequency meters have been secured to make more instruments available for general testing. An alternating current ammeter giving a full scale deflection on 0.01 of an ampere deserves special mention as it extends our laboratory equipment so that alternating current from about 0.002 of an ampere up can be measured by indicating instruments.

An alternating current galvanometer has also been purchased which may be used in place of a telephone or vibrating galvanometer in bridge measurements.

For magnetic tests a Fahy permeameter has been secured. This is a comparatively simple type and at the same time quite accurate for determining the magnetic properties of iron or steel in easily prepared shapes.

A new resistance thermometer for high temperature measurements has been added so that electric pyrometry is now quite well represented.

An electric absorption dynometer has been built in our shop to provide accurate means for testing fractional horse-power motors. It consists of a d. c. generator mounted in a cradle carried on knife edges and has a sensitivity of the order of 0.001 horse-power. Motors up to ½ h. p. can be tested with it.

NEWS NOTES

The annual inter-honorary fraternity dance was held at the Lincoln Park Refectory on the evening of February 10. A crowd consisting of some seventy-five couples of Tau Bet's, H. K. N.'s, P. L. U.'s, Scarabs and their friends turned out and had the time of their lives to the music of Goodheart's famous orchestra. Those who have the idea that the members of the honoraries are followers of Solomon alone, would only have found it necessary to look in at the affair to see that Terpsichore also has his retinue.

* * *

The annual Sophomore dance was held at the Hotel La Salle on the evening of February 17. A large crowd floated about the floor for some four hours to the strains of Bradley's excellent orchestra. The occasion was honored by the presence of Acting President H. M. Raymond and his wife and daughter, Mr. and Mrs. G. S. Allison, Prof. and Mrs. C. I. Palmer, Prof. and Mrs. W. L. Miser, Prof. and Mrs. R. J. Foster.

* * *

The semi-annual Sphinx banquet was held on the evening of February 8. The men taken into the organization at that time were Geo. H. Kelley, Ralph S. Kenrick, and E. Merrill Seaberg. The other members of the Sphinx in school are, W. J. Chapin, Jeff Corydon, Jr., and Warren T. McCaffrey.

The following new men have been pledged since the semi-

annual banquet: L. L. Reihmer, J. V. Lizars, M. C. Nutt, L. E. Grube, and E. H. Christensen.

* * *

The following resolution was passed unanimously by the students at their respective class meetings:

"Resolved that the Armour Institute of Technology should charge, in addition to the regular tuition, an activity fee to cover a subscription to the Cycle, admission to all athletic contests, membership in the Armour Tech Athletic Association, athletics, and health."

This resolution was presented to the various classes by the Armour Tech Athletic Association Committee.

* * *

The Armour Tech Athletic Association Committee while organizing the Athletic Association has carried on many of the duties of such an organization. Under their direction a Song and Cheer contest was started and placed in charge of C. M. Kirkhuff. A sub-committee cares for the visiting teams. An athletic banquet is being planned. A resolution regarding an activity fee was presented to the students through the medium of the various classes. Entertainment is being furnished at the games. Inter-class and inter-fraternity contests are being arranged.

* * *

Prof. Harry McCormack, head of the Department of Chemical Engineering, spoke before the Chicago Library Club on the subject: "Our Chemical Industries and National Defense," on Friday, January 20. The advance notice describes the lecture as "The romantic story of Germany's control of the dye and munition industries and America's struggle for industrial independence through the establishment of the Nitro and Mussel Shoals chemical plants."

* * *

Tau Beta Pi announces the election of the following men, who became eligible at the close of the first semester of their Junior year: L. L. Reihmer, M. E.; W. A. O'Brien, E. E.; P. J. Duerinck, E. E.; B. L. Sites, Ch.E.; V. E. Lowden, E. E.; R. O. Wickel, M. E.; J. W. Spensley, Ch.; E. J. Biever, E. E.; M. C. Nutt, Ch. E.; J. V. Lizars, M. E.

Eta Kappa Nu announces the election of the following men: P. J. Duerinck, J. W. Falconer, L. E. Grube, M. Krebs, R. A. Temple.

ATHLETICS

The 1921-22 basketball season ended February 24, with a hard fought game with Lake Forest College at Armour. The game was fast but Armour stayed in the lead almost the entire time and displayed the type of game that was characteristic of the last few games played. The Augustana game at Armour was the only overtime game played this year and was lost in the last moments of the overtime period, by one point. Lake Forest was quite outclassed on their own gymnasium floor.

Although in the number of games won, the past season was not the most successful that Armour has ever had, the fight and spirit shown by the team was never better. Although handicapped by their training on a small floor and injuries to players, the team never failed to put up a good argument.

Six men won their A. They are: Rutishauser, Schumacher, McLaren, May, Johnson, and Spaid. McLaren was elected captain for the 1922-23 season and from his work this year it is evident that he has the ability and leadership to make a good pilot for next year's squad. Captain Rutishauser deserves a great deal of credit for the way he steadied the team and directed the players from his position as guard.

The Athletic Department is finding it difficult to schedule games with colleges of the rating of Armour Institute for the baseball season as the record made last year seems to have made it undesirable for some of the smaller colleges to play us. About thirty men have reported to coach Leo Walsh for cage practice and many more will probably turn out for outdoor practice.

Games are being secured with Wisconsin University, Chicago University, Notre Dame, Purdue University, Michigan Aggies, Des Moines University, Columbia College and Creighton University. This is the hardest schedule that any baseball team of Armour Institute has ever attempted and the school may expect some good games.

* * *

H. B. Marshall, '05, for thirteen years manager of the St. Louis branch of the Electric Storage Battery Co., has been placed in charge of all railway sales work of the company. Mr. Marshall, who will have his headquarters in Philadelphia, has been connected with the company for the past sixteen years. He entered the employ of the company soon after graduation, taking a clerical position in the Chicago branch.

THE ALUMNUS

Being That Part of **The Armour Engineer** Devoted to Personal Mention of the Graduates of the Armour Institute of Technology and to the Affairs of the Armour Alumni Association.

W. J. Bentley, Armour Institute of Technology, Chicago, Ill.

Officers of the Armour Alumni Association for 1921-22.

W. A. Kellner, '10.................. President
Raymond J. Koch, '13. .... Vice-President
Howard S. White '17............... Treasurer
Walter H. Hallstein '14.....Recording Secretary
Walter J. Bentley '20..Corresponding Secretary
Morris W. Lee '99.......Master of Ceremonies

Board of Managers.

Retiring 1922	Retiring 1923	Retiring 1924
R. M. Henderson '02	C. A. Knuepfer '15	W. D. Matthews '99
J. C. Penn '05	F. C. Dierking '12	Wm. H. Long '02
B. S. Carr '15	Sidney V. James '07	M. A. Smith '10

PERSONALS AND NEW ADDRESSES

'97

Church, E. S., Suite No. 5, 8314 Euclid Ave., Cleveland, Ohio.

Gaylord, T. P., Vice President, Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa.

'99

Fiddyment, S. E., Mechanical Draftsman. H. C. Frick Coke Company, Scottdale, Pa.

Lewis, C. T., General Superintendent, Talisay-Siley Milling Company, Talisay Negros Occ., P. I.

Starkweather, E. V., 63 North Munn Ave., East Orange, N. J., Superintendent, Improved Risk and Brokerage Department, Caledonian Insurance Company, 50 Pine St., New York City, N. Y.

Tarbell, C. L., 617 Vermont St., Waterloo, Iowa.; with the Waterloo Gasoline Engine Company, Waterloo, Iowa.

White, E. C., Electric Outlet Company, 8 West 40th St., New York City, N. Y.

'00

Graff, H. W., Route No. 7, Parkersburg, West Virginia.

Longnecker, C. S., Secretary-Treasurer, The Three L's Electric Company, Traverse City, Michigan.

'01

Baker, E. H., 777 Excelsior Ave., Akron, Ohio.

Swift, J. B., 3825 Wilton Ave., Chicago, Ill.

'02

Anderson, A. H., Assistant Professor, Steam and Gas Department, University of Wisconsin, Madison, Wis.

Briggs, M. H., Vice President and General Manager, The Black Diamond Furnace Company, Monmouth, Ill.

'03

Edgecomb, E. E., with the Zetlitz Company, Riverview and Floral Aves., Dayton, Ohio.

Philips, W. C., Chicago Zoning Commission, 163 West Washington Blvd., Chicago, Ill.

Rawson, H. B., County Surveyor and Rancher, Shelby, Mont.

Weisskopf, M. J., 5837 Washington Blvd., Chicago, Ill.; Secretary, R. D. Weisskopf & Company, Proprietary Medicines, 1714 South Ashland Ave., Chicago, Ill.

'04

Benedict, A. B., 5457 Blackstone Ave., Chicago, Ill.

Byrne, L. J., 3425 Elaine Place, Chicago, Ill.

Coy, F. A., Arnold Brothers, Borland Block, Chicago, Ill.

Davis, R. N., 3935 West Jackson Blvd., Chicago, Ill.

Jackson, A. W., Secretary-Manager, Jackson Iron Works, Los Angeles, Calif. Sends in an enthusiastic report on business conditions in Los Angeles. He is a strong believer in the present application of "Go west young man."

Jens, A. M., 310 Gary Ave., Wheaton, Ill.; member of firm, Fred S. James & Company, 175 West Jackson Bolvd., Chicago, Ill.

Peebles, J. C., 9601 South Seeley Ave., Chicago, Ill.

Pierce, V. C., Superintendent, Car Equipment, Northern Ohio Traction and Light Company, Akron, Ohio.

Wickersham, E. J., 9605 Vanderpool Ave., Chicago, Ill., Consulting Engineer, A. L. Drum & Company, 76 West Monroe St., Chicago, Ill.

'05

Fiske, G. W., Chief Engineer of Gasoline Plants, Shell Company of California, Oilfields, Calif.

Marshall, H. B., Manager Railroad Department, The Electric Storage Battery Company, New York City, N. Y.

Sharp, H. M., The France Stone Company, 1800 Second National Bank Building, Toledo, Ohio.

Vey, Frank, 1301 East Belknap St., Fort Worth, Texas.

'06

Cook, N. W., Architect, 1283 Victor St., Chicago, Ill.

Elkin, M., 1822 West 12th St., Philadelphia, Pa.

Focht, R. G., Structural Engineer, Washington, D. C.

Hepp, A. A., 712 Hinman Ave., Evanston, Ill.

Kuhn, G. W., 427 South Maple Ave., Glen Rock, N. Y.

Lieberman, E., 538 State and Lake Building, Chicago, Ill.

Meyer, E. D., 1908 Carroll Ave., St. Paul, Minn. Is head of the

Meyerlite Corporation, 1128 Metropolitan Life Building, Minneapolis, Minn., which manufactures electric farm lighting plants.

Pierce, F. T., 830 Stoddard Ave., Wheaton, Ill.; Civil Engineer, c-o Louis Levine, 332 South Michigan Ave., Chicago, Ill.

'07

Badger, L. H., Civil Engineer, Maxwell Motors Corporation, Detroit, Mich.; 20 Highland Ave., Highland Park, Detroit, Mich.

Banning, Thomas A., Jr., 600 Third St., Wilmette, Ill.

Dunmore, G. B., Artificial ice business, 364 Chauncy St., Sycamore, Ill.

Henning, C. S. Jr., Division Engineer, State Highway Department, 501 Wheat Building, Fort Worth, Texas.

Jones, H. W., 115 Wellington Ave., Rochester, N. Y.; c-o R. T. French Company, Rochester, N. Y.

Saunders, J. E., 112 Race St., Swissvale Branch, Pittsburgh, Pa.

Sleezer, F. W., 336 Oak Ave., Aurora, Ill. Mail to Assistant District Manager, Western United Gas and Electric Company, LaGrange, Ill.

Wells, J. B., Secretary and Manager, The Kern Sunset Oil Company, Manicopa, Calif.

Wight, R. A., 1231 Ledlie Ave., Springfield, Ill.; Engineer, Illinois Commerce Commission, Springfield, Ill.

'08

Anderson, M. J., Co-Proprietor of Hartford Light and Power Plant, 12 East Shepard St., Hartford, Mich.

Botteron, C. I., 2233 Burlington St., Chicago, Ill.

Cahan, J., 2324 Thomas St., Chicago, Ill.; Arch. Engr., 127 N. Dearborn St.

Ellington, E. S., 2512 Pingree Ave., Detroit, Mich.; Giaver, Dinkelberg and Ellington, Architects and Engineers, 1507 Stroh Building, Detroit, Michigan.

Ettenson, I. Z., with Kilpatrick Purity Baking Company, 753 Santa Fe St., Denver, Colo.

Grant, R. G., 9558 American Ave., Detroit, Mich.; Electrical Engineer, c-o Donahue & Shrebattom Electric Company, 155 Larned Street, West Detroit, Mich.

Laurence, V. E., 1339 Third Ave., North, Ft. Dodge, Iowa; Johnson and Laurence, Auto Dealers, Fort Dodge, Iowa.

Pacyna, A., 1820 Summerdale Ave., Chicago, Ill.; Chemist, The Barret Company, Shady Side, N J.

'09

Downtown, P. G., Manager, Minneapolis Branch, Electric Storage Battery Company, Oxide Battery Depot, 3 North 15th St., Minneapolis, Minn.

Ecklund, C. A., Topographer, United States Geological Survey, Sacramento, Calif.

Ford, T. C., with the Beaver Board Company, 535 Massachusetts Ave., Buffalo, N. Y.

Harger, K., 7207 Harvard Ave., Chicago, Ill.

Heim, C., Business Address: 189 West Madison St., Chicago, Ill.

Johnson, R. W., 4941 St. Anthony Court, Chicago, Ill.; Assistant Engineer, C. M. & St. P. Railroad, 1002 Powers Building, Chicago, Ill.

Niestadt, F. A., with Frank Chase, 645 North Michigan Blvd., Chicago, Ill.

Oberfelder, W., President, The Walter Field Company, 3185 Michigan Ave., Chicago, Ill.

Smith, H. C., no longer at Peoples Gas Company.

'10

Broman, J. G., 7709 South Morgan St., Chicago, Ill.

Kallis, M., 1121 Independence Boulevard, Chicago, Ill.

Kellner, W. A., 643 Arlington Place., Chicago, Ill.

Pashley, E. S., 5948 West Lake St., Chicago, Ill.

Rosenthal, H. I., with the L. L. Summers Company, 140 Nassau St., New York City, N. Y.

'11

Cleaver, T. G., 1624 Highland Ave., Chicago, Ill.

Eickenburg, P., Bond Department, Madison and Kedzie State Bank, Chicago, Ill.

Ferrenz, T. J., 5463 Ellis Ave., Chicago, Ill.

Gault, M. E., 4029 Esmond Ave., Chicago, Ill.

Greengard, B., Architect, 619 North Michigan Ave., Chicago, Ill.

Kuehne, J. H., 3800 Northwestern Ave., Detroit, Mich.; Chief Electrical Engineer, Smith, Hinchman & Grylls, Architects and Engineers, 710 Washington Arcade, Detroit, Mich.

Marx, C. H., 375 Third Ave., Wauwatosa, Wis.; Instructor in Civil Engineering subjects, University of Wisconsin Extension Division at Milwaukee, Wis.

Meyer, J. S., Patent Attorney, 4440 South Racine Ave., Chicago, Ill.

Robinson, J. A. M., 6528 University Ave., Chicago, Ill.

Tobias, W. R., 7154 Sunset Blvd., Los Angeles, Calif.

'12

Bloomfield, J. C., 4449 North Robey Street, Chicago, Ill.

Hess, A. L., 4705 N. Albany Ave., Chicago, Ill.

Malzen, M., 4506 Oakenwald Ave., Chicago, Ill.

Whitaker, D. A., now superintendent of Skinner Manufacturing Company, Dunedin, Fla. Previously Mr. Whitaker was with the Public Service Company of Northern Illinois, and later with J. G. White Corporation on a power plant construction at Muscle Shoals, Ala.

Wolfe, T. F., Secretary, "The Cast Iron Pipe Publicity Bureau."

'13

Bangs, F. T., 6221 University Ave., Chicago, Ill.

Bischof, J. H., 9635 Hampden Court, Chicago, Ill.

Braun, W. T., Architect, 64 E. Van Buren St., Chicago, Ill.

Brown, P. R., 25 Sinclair St., Janesville, Wis. Statistician, Samson Tractor Company, Janesville, Wis.

Buttner, W. C., 921 Buena Park Terrace, Chicago, Ill. Engineer, Bastian Blessing Company, 125 N. Austin Ave., Chicago, Ill.

Cramer, A. C., 2045 Birchwood Ave., Chicago, Ill.

Ermeling, R. W., 5525 W. Ohio St., Chicago, Ill. Architect, 64 E. Van Buren St., Chicago, Ill

Farrelly, J. L., 12247 Harvard Ave., Chicago, Ill.

Fischel, R. E., 423 E. 60th St., Chicago, Ill.

Gibbs, A. D. Married.

Irving, G. F., with Braid & McCurdy, Builders' Supplies, Winnipeg, Canada.

Jarvis, B. H., 6731 East End Ave., Chicago, Ill.

Parson, C. M., 1503 E. 68th St., Chicago, Ill.

Mann, W. C., Commercial Electrical Engineer, General Electric Company, 1318 Pierce Building, St. Louis, Mo.

Pirrie, P. G., 5533 Glenwood Ave., Chicago, Ill. Principal, American Institute of Baking, 1135 Fullerton Ave., Chicago, Ill.

Westlund, E. G., 4333 W. 21st St., Chicago, Ill.

Zillmer, E. G., 431 Norwood Ave., S. E., Grand Rapids, Mich. Architect, c/o H. H. Turner, 923 Michigan Trust Bldg., Grand Rapids, Michigan.

Rothwell, R. F., Supervisor of Production Service Department.

'14

Auer, P. F., 5825 Nine Place, St. Louis, Mo.

Barber, G. S., 715 Summerlea St., Pittsburgh, Pa. Architect, with G. H. Schwam, Architect and Town Planner, 1310 People's Bank Bldg., Pittsburgh, Pa.

Gielow, W. C., 4747 N. Paulina St., Chicago, Ill.
Engineer, Insurance Company of North America, 209 W. Jackson Blvd., Chicago, Ill.

Gumpper, H. D., 70 Virginia Park, Detroit, Mich. Gordon & Gumpper, Industrial Equipment, 1120 David Whitney Bldg., Detroit, Michigan.

Heim, R. M., 3239 Brotherton Road, Cincinnati, Ohio. District Manager, Electrical Engineering Equipment Company, 2611 Union Central Bldg., Cincinnati, Ohio.

Heritage, C. C., 20 Fairchild Place, Buffalo, N. Y. Chemical Engineer, National Analine and Chemical Company, 351 Abbott Road, Buffalo, N. Y.

Hetherington, M. D., Architect, 28 South Dearborn St., Chicago, Ill.

Schmidt, C. G., Des Moines Foundry and Machine Works, Des Moines, Iowa.

Turner, J. W. In charge of Electrical Engineering for the Hoosier Manufacturing Company, Newcastle, Ind., and also designing machinery of their mechanical equipment. Mr. Turner is married and has a daughter.

Willens, Myer J., 743 Waller Ave., Chicago, Ill. North Shore Realty Company, 6804 Sheridan Road, Chicago, Ill.

Zook, R. H., 1538 E. 61st St., Chicago, Ill.

'15

Bready, William, 534 Oxford Ave., Dayton, Ohio.

Deveneau, C Died in Cincinnati, recently.

Diemecke, C, W., 900 Lafayette Parkway, Chicago, Ill.

Hibbard, L. E., 832 George St., Chicago, Ill. Imperial Hibbard Company, Automatic Sprinklers, 8 E. Austin Ave., Chicago, Ill.

Hirschfeld, L. S., 7014 Sheridan Road, Chicago, Ill.

Moeller, A., 7559 Paxton Ave., Chicago, Ill.

Norton, J. C., 576 Martin St., Oakland, Cal. Engineering Superintendent of Pacific Gas & Electric Company, 45 Sutter St., San Francisco, Cal.

Knuepfer, C. A. Business address: 3425 W. 31st St., Chicago, Ill.

Palmer, R. C., 124 Sycamore Park Drive, Los Angeles, Cal.

Petersen, S. M., Room 1107, 64 E. Van Buren St., Chicago, Ill.

Schreiber, E. F., Porter & Schreiber, Architects, 601 Peters Trust Bldg., Omaha, Nebr.

Wilson, R. E., with William Wrigley, Jr., & Company, 3535 S. Ashland Ave., Chicago, Ill.

Bunge, L. W. A., President, L. W. A. Bunge Manufacturing Company, Engineers and Machinists, 2638 W. Madison St., Chicago, Ill.

'16

Apfelbach, H. J., 2133 Fremont Ave., Chicago, Ill.

Armstrong, F. C., 8128 South Park Ave., Chicago, Ill.

Braun, I. H., 6146 Vernon Ave., Chicago, Ill. Architect, 19 S. La Salle St., Chicago, Ill.

Brown, R. B., 5731 Ridge Ave., Chicago, Ill. With the Wisconsin Highway Commission.

Cable, M. L., 3419 Elaine Place, Chicago, Ill.

Cooney, J. G., Assistant Highway Engineer, Illinois State Highway Commission, Brush Bldg., Carbondale, Ill.

Farrier, C. W., Chicago Zoning Commission, 163 W. Washington St., Chicago, Ill.

Kinnally, R. W., 1005 Lowe St., Huron, So. Dak. Highway Engineer, State Highway Commission.

Luckow, L. H., 303 N. Ottawa St., Joliet, Ill.

McHugh, L. J., 1453 Argyle St., Chicago, Ill.

Peek, C., 6405 Kenwood Ave., Chicago, Ill. Architectural Draftsman, c|o Loewenberg & Loewenberg, Harris Trust Bldg., Chicago, Ill.

Peterson, L., 614 N. Harvey Ave., Oak Park, Ill.

Roos, B. L., 734 Elmwood Ave., Oak Park, Ill. Architect.

'17

Bauer, W. E., Jr., 7021 S. Racine Ave., Chicago, Ill. A. E. Bauer & Son, Manufacturers, 1342 W. 69th St., Chicago, Ill.

Botts, T. E., Development Department, Federal Rubber Company, Cudahy, Wis.

Given, L. E., 3008 Montana St., El Paso, Tex. Given Brothers Shoe Company, El Paso, Tex.

Goldberg, L. I., Reed City, Mich. Civil Engineer and Road Contractor.

Levinson, M. B., 1434 S. St Louis Ave., Chicago, Ill. Architectural Draftsman, c|o H. E. Stevens Company, 4231 Monroe St., Chicago, Ill.

Markel, C. H., 608 Sherman Ave., Evanston, Ill. Architect.

Mellor, L. E. Married recently and living in San Antonio, Tex.

Newman, S. W., Wildman & Newman, Building Contractors, 112 W. 42nd St., New York City.

Owen, W. R., 500 Hartman Bldg., Columbus, Ohio.

Roberts, C. H. Member of firm of Isaac D. Roberts & Son, General Insurance Agents, Box 975, Beaumont, Tex.

Smith, A. H., Research Chemist, c|o The Thermoid Rubber Company, Trenton, N. J.

Smith, E. H. Is now at Redbank, Cal.

Starkei, L. E., 925 Oakwood Ave., Wilmette, Ill. Is now back in Chicago selling and promoting the General Cord after having spent three years in Akron, Ohio.

'18

Broyles, J. L., 2223 Ballou St., Chicago, Ill.

Cole, E. R., with Byrne, Byrne & Hahn, Insurance, 175 W. Jackson Blvd., Chicago ,Ill

Johnson, L. R., 908 W. 26th St., Chicago, Ill.

Huffaker, N., Norfolk, Va. Recently married and left for Europe on his honeymoon.

Rook, R H., 59 Prospect Ave., Milwaukee, Wis.

'19

Almlof, W., 6314 Eggleston Ave., Chicago, Ill.

Dady, W. E., 1505 Granville Ave., Chicago, Ill.

Geldmeier, H. F., 1008 French St., Erie Pa. Instructor, Electrical Construction, Jackson High School, Erie, Pa.

Mintz, C. W., 545 Sixth Ave., Pittsburgh, Pa. Manager, American La France Fire Engine Company of Pennsylvania, Pittsburgh, Pa.

Rensch, R. H., 621 Crane St., Schnectadv, N. Y. Is designing apparatus for gun fire control for U. S N. at Schnectady Plant of General Electric Company.

'20

Ablamowicz, S. V., Chief Draftsman, c|o C. E. White, Jr., Architect, Room 213, 343 South Dearborn St., Chicago, Ill.

Clouse, J. H., 812 S. Phillip Ave., Sioux Falls, So. Dak.

Passialis, C., 1219 S. Spaulding Ave., Chicago, Ill.

Peterson, C. F., 2666 E. 77th St., Chicago, Ill.

Wignall, W. J. Married recently and employed in Chicago.

'21

Anderson, F. B. A., 417 Union St., Schnectady, N. Y.

Barce, S. H., with the Flexo-Drive Corporation, 20 W. Jackson Blvd., Chicago, Ill.

Dowse, G. M., 311 N. Washington St., Park Ridge, Ill.

Grill, M. J., Student Engineer, Western Electric Company, Hawthorne, Ill.

Hoven, A. C., Assistant Engineer, McClellan Refrigerating Company, 1150 S. Washtenaw Ave., Chicago, Ill.

Judson, L. D., Assistant Foreman, Litharge Department, National Lead Company.

Kihlstrom, H. C., Duplex Vacuum Motor Company, 5413 S. Halsted, Chicago, Ill.

Lyons, Chicago Zoning Commission, 163 W. Washington St., Chicago, Ill.

Maranz, L. S., 4801 Prairie Ave., Chicago, Ill. Mechanical Engineer, Electrical Inspection Department, Commonwealth Edison Company, Chicago, Ill.

Matson, E. M. Was married to Miss Ruth E. Anderson Wednesday, February 22, 1922.

Miller, F. P., Sales Manager, Special Centrifugal Department, De Laval Separator Company, New York City.

Scherger, R. K., 5228 Michiban Ave., Chicago, Ill. Carter White Lead Company, West Pullman, Ill.

Nedved, R. J., with Tallmadge & Watson, Architects, 189 W. Madison St., Chicago, Ill.

Schiffman, H. M., 3634 S. Michigan Ave., Chicago, Ill. Manager, Acid Supply Company, 5053 S. Halsted St., Chicago, Ill.

Seyferlich, W. M., 439 Wrightwood Ave., Chicago, Ill.

LOCATION UNKNOWN

The Alumni Association would greatly appreciate any information concerning the following:

Anderson, A. G. 1910
Ash, Howard Joseph 1905
Beamer, Burton Evans 1905
Bloomberg, Sheldon 1920
Bowman, D. W. 1910
Brackett, John Charles 1905
Mrs. M. W. Campbell 1900
Charles, Walter Thomas ...1902
Collins, Frank Campbell ...1908
Collins, Frederick L. 1904
Corman, Abraham 1917
Cornwell, Augustus Booker..1908
Crow, Ralph M. 1913
Curtis, Harry S. 1909
Curtis, Marston 1913
Doering, Robert Garl........1911
Dumke, William 1914
Edson, Norman L. 1906
Ehrman, Joseph S. 1913
Emmons, Gilbert C. 1911
Fainstein, Morris 1920
Flanagan, Francis Joseph, Jr.1906
Foy, Edgar Allanson 1916
Friedman, Edward Isaac ...1917
Fryburg, Warren F. 1913
Goldsmith, Frank R. 1905
Griffiths, Francis H.........1911
Schmidt, Fred 1912
Schumacher, Joseph M......1906
Sherman, Max Albert 1915
Sherman, Stanley B. 1903
Smely, James 1920
Snowden, Charles Rossiter .1905
Stanton, Gustav, Jr. 1907
Stark, Andrew Gordon 1915
Summerfield, Myron L. 1917
Tellin, William G. 1911
Tyler, Alva Warren 1905
Wendt, L. J. W. 1903
Wolfe, Edward John 1907
Wright, J. C. 1914
Yoshida, Henry T. 1912

The Armour Engineer

VOLUME XIII. MAY, 1922 NO. 4

SOME POWER REQUIREMENTS OF AIRCRAFT

With Special Reference to the Helicopter.

DANIEL ROESCH, '04, M.E.' 08,

Associate Professor of Experimental Engineering, Armour Institute of Technology.

Classification: Aircraft may be classified as follows:

(1) Lighter than Aircraft:
 (a) Balloons.
 (b) Dirigibles.

(2) Heavier than Aircraft:
 (a) Airplanes.
 (b) Ornithopters.
 (c) Helicopters.

(3) Combination Craft.

Balloons: Balloons have a bag or envelope containing some gas lighter than air and are buoyed up by a force equal to the weight of the air displaced.

Dirigibles: Dirigibles are balloons equipped with engines, propellers, elevators, and rudders to facilitate the maneuvering of the craft.

Airplanes: Airplanes depend for their lifting force upon the velocity of the planes, or wings, which form a part of the device. The planes move with and not relative to the craft. The propelling force is affected by the thrust of one or more propellers revolving in a plane at right angles to the direction of motion.

Ornithopters: Ornithopters have wings, or fins, which flap and furnish the sustaining and propelling forces.

Helicopters: Helicopters depend directly upon the thrust of one or more propellers for their lifting and propelling forces.

Combination Craft: These comprise various combinations of gas bags, planes, flapping wings, and direct lifting propellers,

BALLOONS

The lifting power of the balloon is obtained by subtracting the total weight of the balloon; i.e., envelope, cage, ballast, rigging, equipment, and passengers, from the weight of the air displaced. At the start of an ascent this value must be positive and its amount influences the upward acceleration. The resisting factors are the weight of the machine, the air resistance, and the force required to produce the desired acceleration.

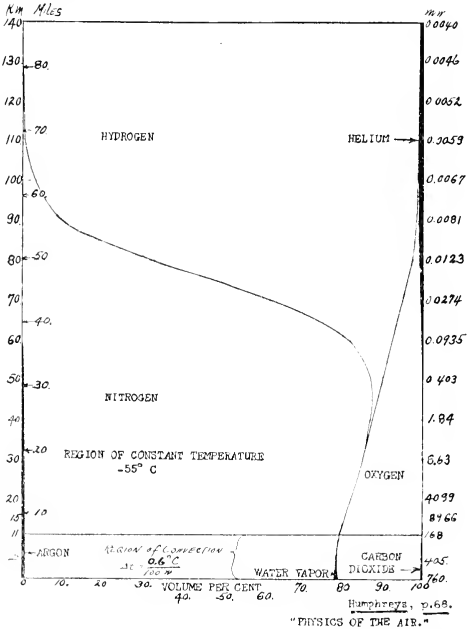

FIGURE 1. COMPOSITION OF THE ATMOSPHERE AT DIFFERENT LEVELS.

The air resistance, or drag, of a sphere is approximated by the empirical formula (Eiffel):

$$D=0.000445V^2A$$

Where D is the drag in lb.

V is the velocity in miles per hour.

A is the cross-sectional area in square feet.

The upward acceleration may be expressed

$$F=m\ a$$

where F is net lifting force of balloon in lb. minus the drag in lb.

m=mass of balloon and parts=$\frac{\text{weight}}{g}$

a=acceleration in ft. per sec. per sec.

The effect of wind has not been considered in the above.

The vertical rise ceases when the balloon reaches an altitude where the air density times the volumetric displacement is equal to the weight of the balloon.

All horizontal and some vertical directional control of balloon movements is effected by utilizing the change of wind direction at different altitudes. Change of altitude is accomplished by throwing out ballast, or releasing gas from the bag. The amount of maneuvering possible in this way is, of course, limited by the amount of ballast carried and the initial maximum altitudes. Besides the free balloons to which the above refers, captive balloons are of great value for observation purposes. These are controlled by cable and winch in a self evident manner.

Balloons carrying scientific recording instruments furnish valuable data pertaining to temperatures, pressures, wind currents, and composition of the air envelope surrounding the earth at high altitudes. Observations have been made up to an altitude of 95,000 feet, or about 18 miles, as indicated in the chart* (Fig. 1). The following reference is made to this chart: "In using this diagram it should be distinctly remembered that it is supported by direct experimental observations only from the surface of the earth up to a level of about 30 kilometers and that, while the extrapolated values are based upon apparently sound logic and not mere surmises, they necessarily become less and less certain with increase of elevation."

DIRIGIBLES

Dirigibles constitute the most important division of the lighter-than-air aircraft. Forward motion of the machine may be effected by the propeller thrust, or from multiple propellers disposed about the center line, the latter permitting also directional control without the use of the rudder. Depression or elevation of the entire machine may be accomplished by proper distribution of propeller thrust and elevators, irrespective of the gas bag influence. The general considerations of forces acting on the dirigibles are similar to those given for balloons, with the added advantages obtainable from the propeller thrusts.

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*Humphreys · The Physics of the Air.

AIRPLANES

Airplanes are today the only practical type of heavier-than-air machine. One or more propellers, usually driven by an internal combustion engine or engines, furnish the thrust which forces the machine through the air. The planes are ordinarily designed for minimum head resistance and maximum lift. The latter is obtained primarily from the vacuum created above the plane and, secondarily, from the increased air pressure below the plane.

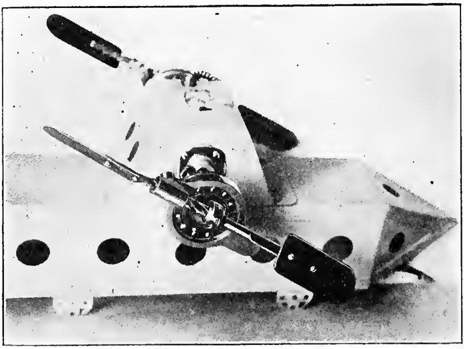

FIGURE 2. JOHNSON OMNIVATER.

An inherent disadvantage of this type of machine is that considerable forward velocity must be present when taking off or when landing in order to provide a lift substantially equal to the dead weight of the machine. In earlier types of machines this minimum speed was equal to about half the maximum speed of the airplane. Recent developments, however, have substantially reduced this lower speed ratio.

Since the armistice Germany has developed many gliders which have added much to the existing data on wing or plane characteristics. The ability to use air currents effectively has resulted in continuous flights of glider and operator for a distance of several miles with practically no loss in altitude.

Extensive study and experimental research in recent years have produced wing surfaces, propeller shapes, and reversible propellers which greatly increase the flexibility of the airplane. The reversible propeller permits changing the pitch to obtain

higher thrust over a wide range of operating conditions, and also permits reversing for braking effect.

ORNITHOPTERS

Fig. 2 shows a model of a Johnson machine having a revolving, feathering wing, or paddle, and illustrates one type of ornithopter. By an ingenious mechanical means, the wing plane is rotated one quarter turn forward and then backward during each revolution about its axis of rotation. The half revolution corresponding to the broadsides position of the wing can be regulated while in motion so that the next effect of air reaction on the wing in the plane of rotation may be horizontal, vertical, or intermediate. Besides the reactions in the plane of rotation, there are reactions on the wing at right angles to the plane of rotation and at intermediate angles during the 90 degree movement of the wing about its blade axis.

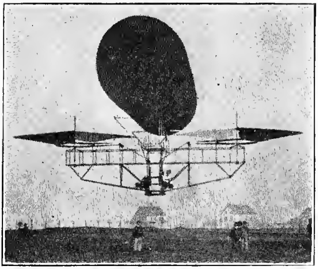

FIGURE 3. OEHMICHEN HELICOPTER IN FLIGHT, SAID TO BE THE FIRST HELICOPTER TO MAKE A FREE FLIGHT, ALTHOUGH IT IS EQUIPPED WITH GAS BAG.

HELICOPTERS

The ideal aircraft is one which can rise and descend vertically, maintain itself at any altitude, move in any direction, or hover over a given spot, and which is structurally non-inflammable. The helicopter appears to embody these characteristics, at least in theory. While the daily and scientific press occasionally announce the successful flight of model helicopters, the writer has found no record of a commercial craft free from gas bags or restraining appliances which has been able to maintain itself in the air. The Petroczy helicopter* is purported to be the first device in the world which after making an ascent has remained hovering in

*Scientific American, June 4, 1921. p. 447.

the air under its own power and without the assistance of a gas bag. While that device was capable of maintaining itself in the air, its movements were controlled by a series of cables. Combination craft comprising gas bags and helicopter propellers have been credited with free flight. The Oehmichen "helicopter," illus-

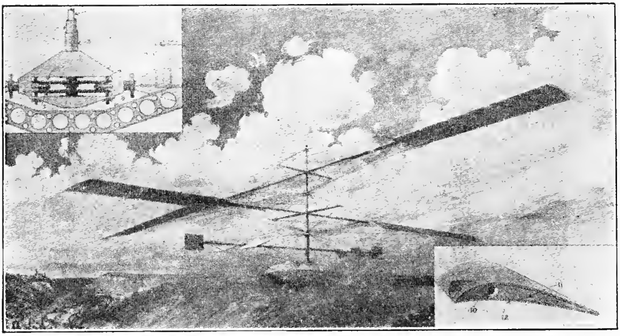

FIGURE 4. HOW THE HELICOPTER OF PROF. FRANCIS B. CROCKER AND DR. PETER COOPER HEWITT WOULD APPEAR IN FLIGHT, AND SOME OF THE DETAILS OF THE TRANSMISSION AND THE REVOLVING WINGS.

trated in* Fig. 3, is said to be the first one to make a free flight. The gas bag in this craft exerts a lifting force of only 20 per cent or so of the total weight of the machine with pilot, while in the dirigible the bag supports the entire load.

Fig. 4** illustrates a Cooper-Hewitt experimental air craft which is a true helicopter. The machine was equipped with electric motors for testing purposes. A total lift of 2,550 pounds, with engine output of 126.5 horsepower, is credited to this device. This corresponds to a lift of 20.2 pounds per horsepower. The propellers were 51 ft. in diameter and operated at 70 r. p. m.

Fig. 5 shows two views of a Leinweber Brothers helicopter embodying means for tilting the propellers so that the direction of the thrust can be vertical or inclined at any angle to the front or rear. Provision for longitudinal balance is made by having four or more sets of propellers and increasing the speed of the propellers on one end. Lateral balance is effected by increasing the speed of the propellers on one side.

*Scientific American, June 4, 1921.

**Scientific American, Dec. 13, 1919.

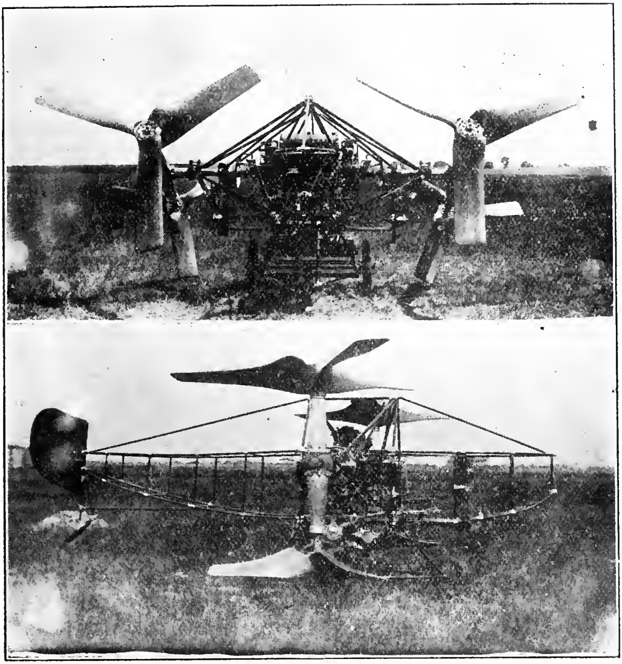

FIGURE 5. TOP-FRONT VIEW OF A LEINWEBER BROTHERS HELICOPTER. BOTTOM—SIDE VIEW OF THE SAME.

The curves in Fig. 6 were plotted by the writer from the data in Table 1 and visualize the relationship of speed, propeller diameter, horsepower, and thrust. From the curves it will be noted that a propeller 8.0 ft. diam.; 1,000 r.p.m.; 40.0 b.hp. and 10 lb. thrust per horsepower has a total lifting capacity of only 400 pounds. This is too small for practical flying purposes.

Fifteen pounds per horsepower can be obtained by reducing the speed to 660 r.p.m., but this will result in reduced power and lift (10 hp. and 150 lb. respectively).

By increasing the diameter to 20 ft., a 15 lb. thrust horsepower will be obtained at 273 r.p.m. and 75 horsepower, with a resultant total lift of 1,125 lbs. Similarly, it will be found from the curve

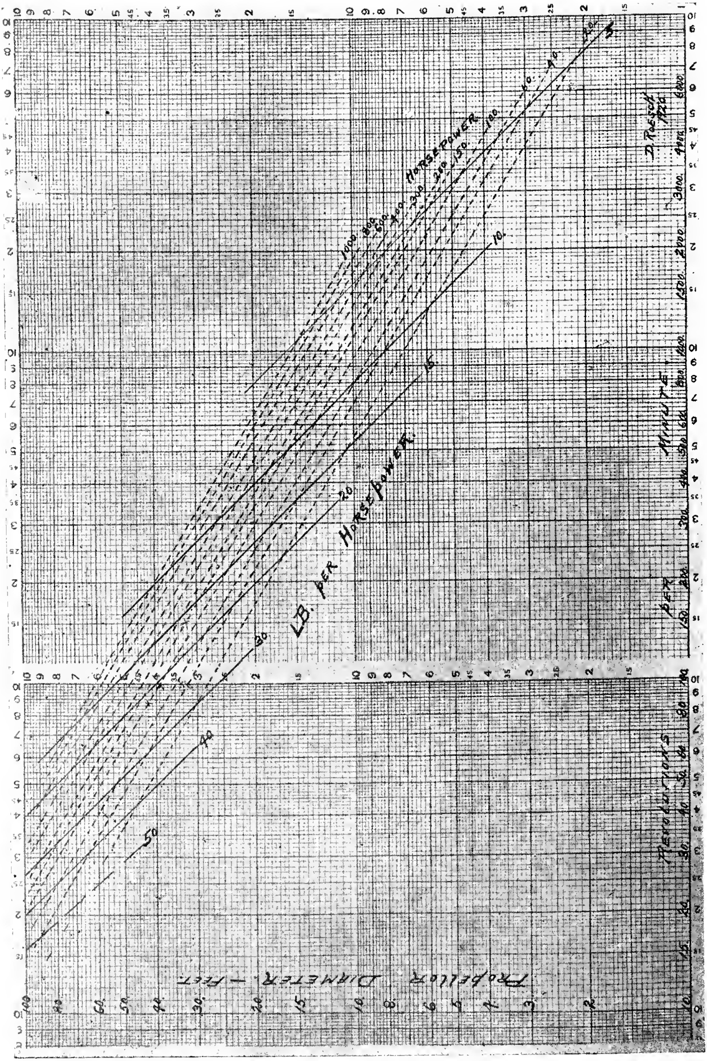

FIGURE 6. CURVE SHOWING RELATIONSHIP OF SPEED, PROPELLER DIAMETER, HORSEPOWER, AND THRUST.

that a 40 ft. propeller at 10 r.p.m. and 120 horsepower will exert a 20 lb. thrust per horsepower and effect a total lift of 2,400 lbs.

The practical zone for propellers suitable for helicopters will undoubtedly be for diameters of 20 ft. or more, speeds of 300 r.p.m. or less, and powers ranging upwards from 50 horsepower per propeller. Standing thrust, as obtained from experimental propellers tested in the laboratories of the Armour Institute of Technology considerably exceed that indicated by this chart. While

TABLE NO. 1 FROM N.A.C.A. TECHNICAL NOTES #4
PROPELLER DIAMETERS IN FEET (R.P.M. in parentheses)

HORSE POWER

LBS. THRUST PER H.P.	20	40	60	100	150	200	300	400	600	800	1000
5	(7740)	(5490)	(4470)	(3460)	(2830)	(2450)	(2000)	(1730)	(1420)	(1220)	(1100)
	2.06	2.90	3.56	4.60	5.63	6.50	7.95	9.19	11.2	13.0	14.5
10	(1370)	(966)	(786)	(612)	(500)	(432)	(353)	(306)	(250)	(216)	(193)
	5.80	8.21	10.1	13.0	15.9	18.4	22.5	26.0	31.8	36.8	41.1
15	(495)	(351)	(286)	(221)	(181)	(157)	(128)	(111)	(90.6)	(78.6)	(70.2)
	10.7	15.1	18.5	23.9	29.2	33.8	41.3	47.6	58.5	67.5	75.5
20	(242)	(171)	(140)	(108)	(88.8)	(76.8)	(62.4)	(54.2)	(44.2	(38.2	(34.3)
	16.4	23.2	28.4	36.7	44.9	51.9	63.6	73.4	90.0	104	116
30	(87.6)	(61.8)	(50.7)	(39.2)	(32.1)	(29.3)	(22.6)	(19.6)	(16.1)	(13.9)	(12.4)
	30.2	42.7	52.3	67.5	82.6	90.5	117.	135.	165.	191.	214
40	(42.9)	(30.2)	(24.7)	(19.1)	(15.6)	(13.5)	(11.0)	(9.5)	(7.8)	(6.8)	(6.1)
	46.4	65.6	80.4	104	127	147.	180.	208.	254.	294	328
50	(24.5)	(17.3)	(14.2)	(11.0)	(8.9)	(7.8)	(6.3)	(5.5)	(4.5)	(3.9)	(3.5)
	60.5	91.1	112.	145.	178.	205	252	290	356	411	459

these experimental propellers were of the smaller sizes, similar runs upon 8 ft. to 10 ft. 6 in. diameters made in the field also showed results which exceed the chart values. The chart, however, offers a simple and rapid means of comparing the standing thrust performance of propellers. Some idea of the weights per horsepower used in airplanes may be gained from the following examples:

Machine.	Wt. per HP. (Pounds)
Verille	8.15
Loening	8.32
Lepere Triplane	10.25
Martin (with bombs)	12.3

Instead of fitting each engine with an independent propeller, it may be desirable to install a central power plant with the propeller at a distance. This construction permits of a multiple engine

drive with one or more propellers. The relation between r.p.m., engine horsepower, and propeller thrust for a number of combinations may be gained from an inspection of the curves in Fig. 7. Referring to the figure, it will be seen that the intersection of the engine power curves with the propeller horsepower curve locates the speed and, therefore, the thrust of the propeller. The values represented by the curves are for a specific set of conditions and not general. Relative air speed, air density, direction of thrust, engine characteristics, and many other factors influence the results and the curves should be used with this in view. The data in Table 2 are based upon the curves in Figs. 6 and 7.

Table 2

	Engine.			Propeller (½ engine speed).			
No.	R.P.M.	B. Hp.	B. Hp. Per cent	R.P.M.	Thrust lb. Per hp.	Thrust lb. Total	Thrust Pct.
4.....	1450	410	100	725	7.3	2990	100
3.....	1360	320	78	680	8.0	2560	85.6
2.....	1210	205	50	605	9.0	1840	61.5
1.....	915	85	20.7	467	11.5	980	32.5

The chief objection to the helicopter is that of forced descent in case of engine or propeller failure. Other limitations are lack of stability and uncertainty of control. These objections may be minimized by:

(1) Use of reversible pitch propellers, which will act as a brake on descent.

(2) Incorporation of a small plane to be used for volplaning.

(3) Incorporation of a gas bag of desired size.

(4) Use of collapsible gas bag opened when desired by a very light gas carried under high pressure.

(5) Use of collapsible parachutes, forcibly opened.

(6) Combination of any of the above.

SUMMARY

The dirigible and the airplane have already proven their great usefulness. The helicopter has been given greater study than the ornithopter and is receiving considerable attention because in theory at least it embodies all the essential elements of the ideal aircraft. The high pressure wind tunnel at Langley Memorial Field will be available for experimental investigation of

models of various types of aircraft. Dr. Ames, Professor of Physics at Johns Hopkins University and Chairman of the Executive Committee of the National Advisory Committee for

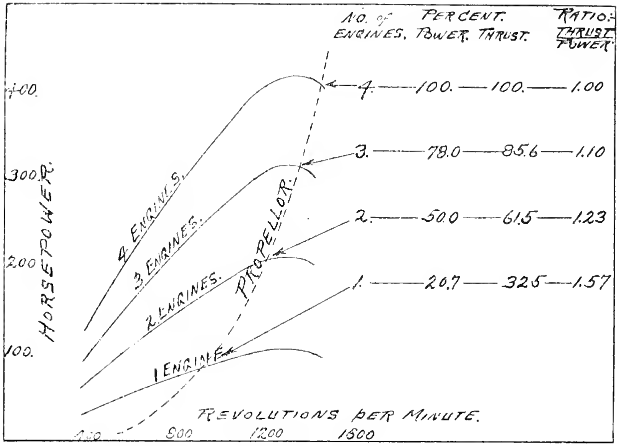

FIGURE 7. CURVE SHOWING RELATION BETWEEN R. P. M., ENGINE HORSEPOWER AND PROPELLER THRUST FOR A NUMBER OF COMBINATIONS.

Aeronautics, describes the reason for building such a tunnel, in an address before the Section of Physics and Chemistry of the Franklin Institute as follows:

Four physical quantities involved in the aerodynamical action are: The velocity of the air, its density, its viscosity (i. e., measure of the frictional property), and the size of the solid body, as given by its length or its thickness. Lord Rayleigh showed many years ago that if we formed the quantity

$$\frac{\text{density x velocity x length}}{\text{viscosity}},$$

which is now called the "Reynolds number," we would be justified in saying that the properties observed in any experiment would also be found to be the same for any other experiment having the same "Reynolds number." It is seen by looking at

the definition of this number that we can have the same Reynolds number for a large number of different experiments. Thus, compare an actual airplane in flight at 90 miles per hour, say, with a wind tunnel experiment on a model of one-twentieth scale by having the same velocity of air flow. If the Reynolds number is to be the same for the two cases, it is necessary to increase the density of the air in the wind tunnel twenty-fold. . . . In view of the great importance of this matter, the National Advistory Committee for Aeronautics has designed and has now underconstruction at Langley Memorial Laboratory such a tunnel, in which the air may be so compressed to 25 atmospheres.

PROGRESS

Contrast often tells a story: the great Corliss engine exhibited at the Centennial Exposition at Philadelphia in 1876,, was of the then unprecedented capacity of 1,400 hp. and rotated at 36 R. P. M. Contrast with the present largest trubo-generator of 80,000 hp. (60,000 kw.) at 1,800 R. P. M. What this advance and progress in the science of generation of electricity alone has meant to the human race in the conservation of its natural resources can best be illustrated by the amount of coal which would have to be burned today to produce the demand for central station energy if it had to be generated by the type of Colossus Corliss exhibited at the Centennial Exposition. It is figured conservatively that the saving effected in a year's time, in this respect alone, amounts to not less than 21,000,000 tons, which if taken even at the very low average price of $2.50 per ton delivered, represents a yearly saving of $52,500,000 to the country at large.

HEAT FLOW THROUGH BUILDING WALLS

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The problem of heat losses through building walls is one which is of special interest to heating engineers, architects, and builders. But it should also be of interest to everyone who contemplates buying or building a home, because the comfort of the occupants, both in winter and summer, will depend to a very large extent upon the heat-retaining quality of the walls. It is the purpose of this paper to discuss heat flow through building walls, with special reference to those types of construction which are usually used in the building of dwelling houses.

In the entire field of physical testing of materials as carried on by the engineer or the physicist, there are perhaps few tests in which a greater disparity in results has been noted than in the testing of thermal insulators. As a result of this seeming lack of agreement among different investigators in this field, architects and builders have been inclined to go ahead with their standard forms of construction, without paying much attention to the improvement of their buildings through the use of insulating material, properly applied. Such a state of affairs is particularly regrettable at a time when organized efforts are being made to promote the "own your home" movement. Anything which contributes to the comfort and satisfaction which a home owner secures from his home should have the serious consideration of those whose business it is to design and build homes. Among such contributing factors properly insulated walls, roofs, and floors, without doubt take a high rank.

In presenting test methods and data on heat losses through building walls, it is desirable that some of the general aspects of the problem be considered in order to make clear the exact nature of the results which the tests are designed to bring out. For this reason the following brief outline of the nature of the problem is presented:

According to the second law of thermodynamics, heat will flow from one point to another only when there is a difference in temperature between the points, and the direction of the flow is

towards the point of lower temperature. In other words, heat flows downward along a temperature gradient, and if, in any particular case, the fact of heat flow in a particular direction is established, the existence of a temperature difference between any two points in the path of heat flow is likewise established. Consider the particular case of heat flow from the air of a room through the exterior wall into the outside air. Inasmuch as heat is flowing *from* the air *to* the interior surface of the wall, it follows that the latter is at a lower temperature than the layer of air immediately in contact with it. Again, this first layer of air is at a lower temperature than the second layer next to it, and so on (considering for convenience that the air is arranged in layers) a successive temperature difference exists, gradually merging, however, into the uniform temperature of the mass of air in the room.

A similar condition is found on the exterior surface of the wall where the heat is escaping into the outside air. The surface of the wall is at a higher temperature than the air in contact with it, a temperature gradient existing from the wall a certain distance into the air. On account of the fact that the outside air is rarely if ever quiet, the heat does not escape from layer to layer by conduction, but is quickly swept away by convection currents. For this reason the temperature gradient does not extend as far from the wall on the outside as on the inside and the observable temperature difference between air and wall surface is less on the outside.

It will be evident from the above considerations that when heat flow through a wall or other thermal insulator is to be measured the exact points at which the temperature observations are made is of importance. It is customary to express the heat flow in b.t.u. per square foot of surface per hour per degree Fah. difference in temperature. This temperature difference is the most important factor in the equation of heat flow, and for the experimental investigator the most difficult to determine with uniformity and accuracy under all conditions.

As the result of much work along this line of industrial or commercial research two forms for expressing heat flow are now fairly well established. In one the temperature difference, surface to surface, is used, while in the other the air to air temperature difference is employed. Manifestly the results will be very

different according to which method of expression is used, although the actual heat flow is exactly the same in both cases. If surface to surface heat flow is wanted, the surface temperature of the material must be measured, and not that of the air in contact with those surfaces. This is not so simple as it might appear, a thermometer being practically worthless for the purpose on account of the size and surface of the bulb. On the other hand, if air to air heat flow is to be measured, where shall the temperatures be observed? Obviously outside the temperature gradient, so that the temperature difference measured is the real difference between the mean levels of inside and outside temperatures.

Tests of air to air heat flow are usually made in some form of calorimeter box or hot box. Five sides of the box are built of cork or other material of high thermal resistance. The sixth side is composed of the material the conductivity of which is to be measured. Heat is applied to the interior of the box by passing an electric current through a resistance coil, distributed uniformly throughout the box. Often a small electric fan is placed in the test box to promote a gentle circulation of the air and so tend towards a uniform distribution of temperature. The mean temperature of the air in the box is obtained from the readings of several thermometers uniformly distributed. Likewise the mean temperature of the air in the room where the test box is located is measured with thermometers, and the air to air temperature difference calculated.

Before making any tests the box must first be calibrated. To do this the side upon which the test samples are to be placed is closed with material of the same kind and thickness as the rest of the box. Heat is then supplied to the interior of the box at a constant known rate and continued until the mean temperature therein becomes constant. The room temperature must also be kept constant during the test. The rate of heat flow through the walls of the box is now equal to the known rate of heat input from which the heat flow per degree of temperature difference is readily calculated. This gives the constant of the box which should be expressed in b.t.u. lost per hour per square foot of mean wall surface per degree Fah. difference in temperature.

The sixth side of the box can now be removed and the material to be tested put in its place. The heat is again turned on and continued until a constant temperature inside the box has been

reached and maintained for about eight hours. The heat loss through the five original sides of the box being known from the calibration, it is only necessary to subtract this loss from the total heat supplied to give the loss through the test sample.

The Postal Box, adopted by the U. S. Government as a standard for the testing of walls for mail cars, has two removable sides, which can be replaced by two similar samples of the material to be tested. This box has also been used extensively by the testing departments of many of the railroads for testing insulating materials to be used in refrigerator car construction. Norton* has made use of a box in which the lid was composed of the material under test the sides and bottom being made of cork or other insulating material of known heat conductivity. Willard† and Lichty† have made use of a hot box constructed entirely of the material under test, as has also been done by Wood‡ and Grundhofer‡. In general such boxes are superior to those in which only one or two sides are composed of the material under test. However, in testing full size wall sections it is difficult and expensive to construct a box entirely of the materials to be tested, especially when quite a number of wall constructions are to be investigated. Experience in the use of a box similar to the one used by Norton shows that consistent results may be secured if the test conditions are kept substantially constant. If in all tests practically the same temperatures are used, air conditions are unchanged, and samples are not of excessive thickness, reliable results can be secured.

It is to be noted that the results of hot box tests of heat flow are expressed per degree of difference between the mean temperature of the air inside the box and the air in the room outside the box. Furthermore, the space inside such a box is comparatively small and contains a heating element of resistance wire. Care must be taken that the temperature readings are not unduly affected by this heating element which may be quite warm. Unless a standard box is used and the temperatures are measured according to a standard practice it is unlikely that different experiment-

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*A Study of the Heat Transmission of Building Materials, by Willard and Lichty. Bul. No. 102, Engr. Exp. Station. Univ. of Ill.

†Thermal Properties of Concrete, by C. L. Norton. Jour. A. S. M. E., Vol. 35.

‡Heat Transmission of Corkboard and Air Spaces, by Wood and Grundhofer. Bulletin No. 30, Engr. Exp. Station, Penn. State College.

ers will secure the same mean temperature for the same rate of heat flow. The discrepancies which have been noted in the results of different tests on heat conductivity by the hot box method are due very largely to the method used for determining the inside temperature. Results of such tests are practically without value unless accompanied with a detailed statement as to how the tests were conducted.

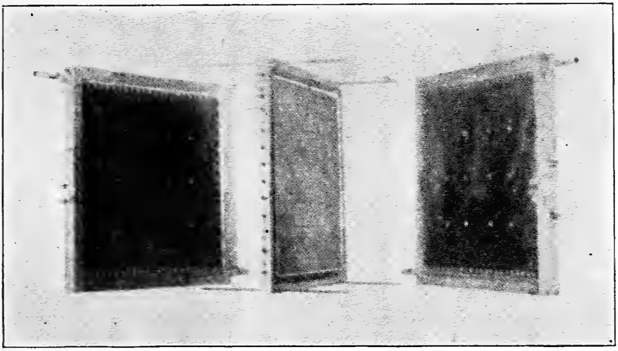

Fig. 1. The Three Plates Ready to Assemble.

Surface to Surface Heat Flow

When it is desired to compare the heat insulating properties of two or more materials, the thermal resistance of the air contact surfaces should be eliminated and surface to surface heat flow expressed. Some form of flat plate instrument will usually be found most suitable for such tests. The instrument used by the writer consists of three plates, as shown in Fig. 1, designed to take test samples approximately 18″ square. The middle plate is heated electrically by means of a flat resistance ribbon wound uniformly over both surfaces of a slate core 18″ square and 1″ thick. The winding is covered with sheet mica for insulation and the whole covered with a copper plate, one on each side. On each side of the hot plate is mounted a cold plate through which constant temperature water may be circulated. Two pieces of the material to be tested are used, one on each side of the hot plate and each backed up by a cold plate.

From an examination of Fig. 1 it will be seen that the two copper plates covering the two faces of the hot plate have their center portions cut away. The piece cut away measures 9" square leaving an outer portion or guard ring approximately 4½" wide. The central square is put back in place and connected at each corner to the guard ring portion by soldering in a short piece of "Advance" wire. Thus the only connection between central square and outer guard ring is in the four pieces of "Advance" wire. Copper leads are connected to central square and outer guard ring, respectively, and run to a galvanometer or pyrovolter. When the instrument is in use any escape of heat laterally from the edges of the hot plate lowers the temperature of the guard ring below that of the central square and an electromotive force is indicated on the pyrovolter, due to the thermocouple action of the four pieces of "Advance" wire. An auxiliary or compensating coil is wound around the edges of the hot plate by means of which additional heat is supplied to the guard ring. The current in this coil is adjusted until the galvanometer reads zero, at which time central square and outer guard ring are at the same temperature. Inasmuch as the central 9" square is the portion under test all heat supplied passes through the test material, none escaping from the edges. In Fig. 2 the apparatus is shown assembled, with test specimens in place.

Temperature differences between hot plate and the two cold plates are measured with copper-advance thermocouples calibrated in degrees Fah. The maximum temperature at which the hot plate can be used is about 200 deg. Fah., higher temperatures affecting the mica board insulation. The cooling water can be maintained successfully at about 40 degrees Fah., giving a maximum temperature difference of 160 degrees Fah.

Inasmuch as there is a flow of heat from the copper surface of the hot plate to the material under test and from the latter to the cold plate, there must be a difference in temperature at each of those contact surfaces. Again, the temperature differences measured are those between hot plate and cold plate, which evidently are not the surface temperatures of the test material. However, if there is a good contact between the plates of the instrument and the material under test, and if the latter is a fairly good thermal insulator so that the total heat flow is small, it is found that the temperature differences at the contact surfaces necessary to produce this flow are very small, due to the high thermal conductivity

of the copper. Thus the results secured give substantially surface to surface heat flow if the limitations of the instrument and the method are kept in mind. The U. S. Bureau of Standards has used this method for testing thermal insulators and has published considerable data on the subject. The method is more accurate than the hot box, but it should be kept clearly in mind that the two methods measure different physical quantities and hence should not be compared directly.

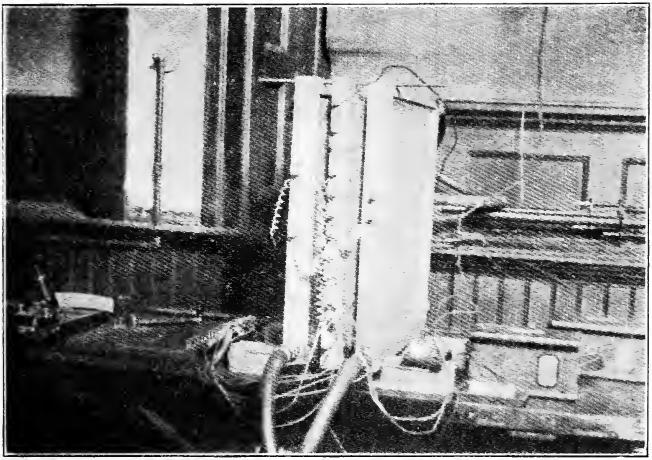

Fig. 2. Apparatus with Specimens under Test.

The resistance which a wall presents to the flow of heat may be divided into three factors: 1. Contact resistance between the inside air and the wall surface. 2. Thermal resistance of the wall, surface to surface. 3. Contact resistance between the outer wall surface and the outside air. Inasmuch as we have no convenient unit to express thermal resistance, the reciprocal, conductivity is used. Let

Si=B.t.u. per hour passing into one square foot of inside wall surface per deg. Fahr. difference in temperature between wall surface and air.

So=B.t.u. per hour escaping from each square foot of outside wall surface per deg. Fahr. difference in temperature between wall surface and air.

C=Thermal conductivity of wall, surface to surface, expressed in B.t.u. per hour per square foot per deg. Fahr. difference in temperature.

U=Coefficient of heat transfer, air to air, expressed in B.t.u. per hour per square foot per deg. Fahr. difference in temperature.

Then

$$U=\frac{1}{\frac{1}{Si}+\frac{1}{C}+\frac{1}{So}}$$

It should be noted that the flat plate instrument measures "C" of the above equation while the hot box method determines the value of "U." It is possible, however, to determine all of the factors in the above equation from the hot box test. In addition to thermometers or thermocouples to give the mean inside and outside air temperatures, couples must be installed to give the inside and outside surface temperatures. Fine wires should be used for the couples with junctions as small as possible. If the material under test is of a woody or fibrous nature a very fine shaving can be raised with a sharp knife and the thermo-junction placed under it. This gives much better results than can be secured with a thermometer. When rate of heat flow, air temperatures, and surface temperatures, are known it will be evident that Si, So, and C can be readily calculated.

The tests on building walls submitted below were carried out on a hot box conductometer in which the sample to be tested constituted the top. The bottom and sides of the box were made of 3" cork board backed up on the outside with ¾" wood sheathing. The calibration of the box at a temperature difference of 70 deg. Fahr. gave a conductivity of 0.105 B.t.u. per square foot of wall surface per degree Fahr. per hour. The surface of the test sample exposed to the heated air in the box measures 33"x33" or 7.56 sq. ft. Temperatures inside the box were measured with 12 copper-advance thermocouples, and room temperatures with thermometers. The samples tested are as follows:

TEST SAMPLES

No. 1. Ordinary wood construction, 2"x4" wood studs with wood lath and gypsum plaster of a total thickness of 1¼" on inside, and sheathing and drop siding 1¾" thick on outside.

No. 2. Ordinary wood construction, same as sample No. 1, but using metal lath instead of wood lath.

No. 3. Ordinary wood construction, same as sample No. 2, but with addition of one thickness of building paper between sheathing and drop siding.

No. 4. Stucco construction, same as sample No. 2, with addition of 1 1/16" Portland cement stucco on metal lath, furred out with 3/16" furring strips laid on building paper stretched over the drop siding.

No. 5. Back plastered stucco construction, consisting of 2"x4" wood studs, metal lath furred out on 3/16" pencil rods with 1 1/16" Portland cement stucco on outside. On the inside building paper, metal lath, and 1¼" gypsum plaster.

No. 6. Back plastered stucco construction same as sample No. 5, but having two thicknesses of building paper instead of one.

No. 7. Back plastered stucco construction same as sample No. 5, but having 3-ply Cabot's quilt instead of building paper.

No. 8. Six-inch hollow clay tile, covered on the outside with ⅞" gypsum plaster.

No. 9. Brick Veneer consisting of ordinary wood construction like sample No. 2, but with drop siding removed and one course of brick substituted.

Results of Tests

Sample Number	Thickness Inches	Weight Lb. per Cu. Ft.	Temp. Diff. Deg. Fahr.	Conductivity
1	6¾	24.5	69.1	0.390
2	6¾	26.2	68.8	0.406
3	6¾	26.2	69.1	0.378
4	7 15/16	40.8	70.7	0.352
5	6 5/16	49.5	62.4	0.427
6	6 5/16	49.7	66.8	0.394
7	6 5/16	50.0	71.7	0.323
8	7¾	59.1	69.3	0.642
9	9 5/16	53.6	68.2	0.537

From the above data it will be seen that the introduction of insulating material into a wall reduces the heat flow very materially. Even a single thickness of building paper has a noticeable effect, as shown in samples 2 and 3 above, in which the use of building paper reduced the heat flow approximately 7 per cent. Also, a comparison of the standard back plastered stucco construction, sample No. 5, with a similar construction in which Cabot's quilt has been used (sample No. 7) shows a reduction in heat flow of nearly 25 per cent. There can be no reasonable doubt that if insulating material, such as Cabot's quilt, flaxlinum, celotex, insulite, etc., were used in dwelling house wall construction, the result would be a cooler house in summer, a warmer house in winter, and a substantially reduced coal bill. Of course, the cost of such insulating material would add to the investment in the building, but the saving in coal bills alone will pay a generous interest on the additional investment.

THE ENGINEER IN THE COMMUNITY

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A criticism has often been made that engineers are not qualified as business men and executives. They are recognized as efficient advisers, but are usually considered too narrow in their opinions and too inexperienced to deal with business affairs in a broad way or to assume leadership in community affairs. Certain other lines of business and professions, notably lawyers and bankers, seem to furnish most of the leaders in the business world and in civic affairs. It is even noticable when an engineer becomes the executive head of an organization and he is often given the credit of being an exceptional man because he has risen from such a depth of obscurity.

Now what may we say about this situation? Some may say that the engineer does take his proper place and receives advancement and favor from the public so far as it is due him, but select the leaders of civic activities and the molders of public opinion in any community and see what a negligible proportion of them are engineers.

Several reasons may be advanced why this is so, and most of these reasons are due to a lack in the engineer himself. With all the indifference of the average citizen to public affairs, and the opportunity thus given for unworthy men to advance themselves in power, still the judgment of the public is correct in the main, and if the engineer has failed to receive recognition either he has not rendered service, or the public believes he is not competent to do so.

The engineer should recognize his duty to participate in public activities. This is a duty incumbent upon every citizen, but especially upon those who have enjoyed superior advantages. A large proportion of engineers have been educated in state universities or other publicly supported schools and it is only fair that they should make a return in some manner to the public for what they have received. The support of these schools is maintained for promoting the public welfare and not for the advancement of a few students who will accept these privileges and use their acquired abilities for their own purposes only. Even in private

schools, not supported from the public treasury, it has been necessary for public spirited men to give financial assistance and this is done because it is considered a public benefit. Every man's education has been an expense to the community and on the lowest basis of fairness he should use his ability to make some return.

Again the altruistic feelings of every man should prompt him to render some service to the community of which he is a part. He certainly receives benefits because of community activities and in fairness ought to use some portion of his ability for the public good.

Then why does the engineer not take a more prominent part in public affairs? We cannot admit that because of his profession he has less desire to do so than men of other callings. Neither can we allow the idea that he does not realize its necessity as well as any other citizen, because his judgment certainly has not been impaired by his education, else it has been poor engineering training. His particular ability along technical lines certainly does not disqualify him for public service because many features of such service would be better for his greater interest and knowledge. One reason that has been assigned is that as an employee he is not at liberty to use his time and ability as he may desire, and that the interests of his employer may be impaired by such activity. To some extent this is a valid reason because much of the engineers work must be for large companies, and there is not the opportunity for individual freedom that may exist in a smaller organization. Such a restriction also applies to many men who are active in public affairs, but whose education has been along different lines.

But the real reason I believe is that the training of the engineer has been based almost exclusively upon the study of *things* and very little upon the study of *men*. In other words, the engineer by training is an expert in physical relations and a novice in human relations. The engineer studies materials and physical laws and his whole activity is centered in these relations. Such a study has its fascinations and the deeper one delves in at any point the more marvelous the physical world seems. There is a constantly increasing complexity in all its relations which baffles the human intelligence and yet spurs it on to ascertain more and more of the secrets of nature. As investigation proceeds there gradually emerges some conception of unity underlying all the diverse phe-

nomena and the student becomes convinced that the physical universe and its laws is not a haphazard collection of isolated facts but is a marvelous mechanism operating in an orderly and definite manner and controlled by immutable laws which cannot be defied with impunity.

The true engineer is thus a close student of material phenomena, but he is not a materialist, because it is impossible to be familiar with such a marvelous machine as the physical universe and then to assume that it just developed without plan or thought. It is beyond his experience that such should be the case because he knows of the severe effort and thought necessary to produce some of our relatively simple human devices. But whether or not one thinks deep enough to realize this it is certain that he must recognize the supreme significance of physical law. It exists, we must recognize it, and we must conform to it or suffer the consequences. There will arise a respect for the truth as expressed in the law and a recognition of the futility of combatting it. Thus, on grounds other than moral, the student will have a wholesome regard for truth. A real engineer cannot then be a dishonest man.

This knowledge of the relation of physical things and the laws governing them is essential to the engineer but it alone does not properly equip him for life. It does not give him even a fair chance in comparison with the man who knows men and the motives which govern them. In all activities the human element must be considered and the engineer has not been properly trained to handle that element. With the ever increasing complexity of our industrial life this human element is becoming more and more predominant. The engineer has not fulfilled his full duty because he has heretofore limited his field of activity to physical relations only and has left to others the handling of the human relations. He has taken the relatively simple and easy portion of the work and allowed others to do what he might readily do. The engineer is inherently as competent to handle human relations as physical ones, and when he has done so it has been with great success, as is evidenced by numerous conspicuous examples.

Labor is not a commodity to be handled as so much material in production. It is just as important an element, and usually more important, than any material entering into production, but it is subject to a different mode of treatment. Materials are

manipulated only by conforming to physical laws and labor can be properly handled only by recognizing its human attributes. It of course, must be directed, and as labor, it cannot be allowed to substitute itself for management but it can be fairly treated by recognizing its human quality. In any industrial or commercial project there is the material, the labor, and the management. The engineer has been trained to handle the material side, he should also be trained to handle the labor problems that inevitably arise, and if he is competent in that, then nothing can prevent his assuming the management of many enterprises from which he is now apparently debarred.

Possibly it may be said that the engineer is fulfilling his duty when he confines his activities within the limits of his own technical abilities. But the technical activities do not cover the entire engineering problem which must be solved. The economic and human elements are to be considered as completely as the technical, and the engineer may well be the one to co-ordinate them and devise a rational and fair solution.

The lawyer, the banker and the merchant have through all their business life dealt with the human element more than with the material side, and naturally when the direction of large enterprises is involved these men are the ones chosen to lead. They are more likely to succeed as executives because they know better how to handle the human problems. Except for this reason the engineer is perhaps better qualified as a leader in industry than any other type of man. There is no reason why an engineer should not be the executive head of an organization and have lawyers and bankers as his aides, instead of a lawyer being at the head and employing an engineer in a subordinate capacity as his adviser in many things.

But the case is far from hopeless for the engineer because he is really beginning to realize the situation. His intense enthusiasm and interest in his chosen work has heretofore so absorbed him that he has cared for little else. The enormous growth in industries, the demand for labor saving devices, for speed and efficiency in production, for better transportation, and better living conditions have all made greater demands on the engineer and have brought the public to a better realization of how many things in modern life are due to his efforts and skill. These things have a tendency to bring the engineer to his proper place in the com-

munity, but the development of his ability to deal with the human elements of his projects will do more than anything else to make him one of the most valued members of society in its community activities.

The curriculum of the modern engineering course is now much crowded and it would seem impossible to add to it. But in the courses as they are it would be feasible to introduce more of the human point of view without sacrificing any efficiency in the technical instruction. The chief business of the college course should be to teach fundamental facts and principles with their applications to engineering problems. The practical problems as they are met with in the business world involve not only the handling of the technical phases but of the human elements also and the study of the principles underlying both are important. The college course should lay emphasis upon principles and methods rather than upon the acquisition of information. It is easier to ascertain facts and apply them to any particular problem which arises if methods of attack have been studied. Rarely do we have the same combination of facts and the same problems to solve in practical business projects that we have learned in college, and if we are skillful in methods of solution, we are much better qualified than if we have only an accumulation of facts, however important such facts may be. The conclusion of the matter is then that the engineer's training should be based more fully upon a sound study of the actions of men as well as of material things, thus acquiring an ability to handle engineering problems in all their phases.

THE SUBSTRUCTURE OF THE WABASH ROUGE RIVER BRIDGE AT DETROIT, MICH.

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The construction of the substructure of the Rouge River Bridge is of interest as it presents both the pneumatic caisson and open excavation work. Four concrete cylinders 12 feet in diameter were sunk to rock and one rest pier extending about 18 feet below the bed of the river were constructed. While there was no radical departure from general engineering practice, a brief description will be given of the methods adopted in carrying the work to a successful conclusion.

The Rouge River is a small tributary of the Detroit River and a part of its course is the city limits line of the city of Detroit. It has been classed as a navigable stream by the War Department since 1891, when the former draw span across the river was erected. In conjunction with extensive developments of the Ford Motor Company, located on the river, the U. S. government authorized the widening of the channel to 300 feet with a depth of 20 feet, and a minimum width through the bridges of 125 feet. To comply with these requirements, it became necessary for the Wabash Railway to reconstruct its draw span.

The Government in its order required the Wabash to begin construction by April 1, 1920, but at that time the design or type of bridge had not been definitely settled. Within the month, it was decided that the new structure would be of the trunnion bascule type, and bids were received for the masonry work. The contractor was permitted to use either square or round piers and to select his own design for the cutting edge. The contractor decided to build cylinder piers, using collapsible metal forms and submitted a plan for a circular cutting edge and a working chamber eight feet in depth made of one-half inch boiler plate steel with walls of reinforced concrete which were approved by the chief engineer.

It was not deemed necessary to go to the expense of drilling test-holes or making borings to determine the nature of the subsoil and elevation of bed-rock as such information was available from the Michigan Central railway bridge one-half mile down-

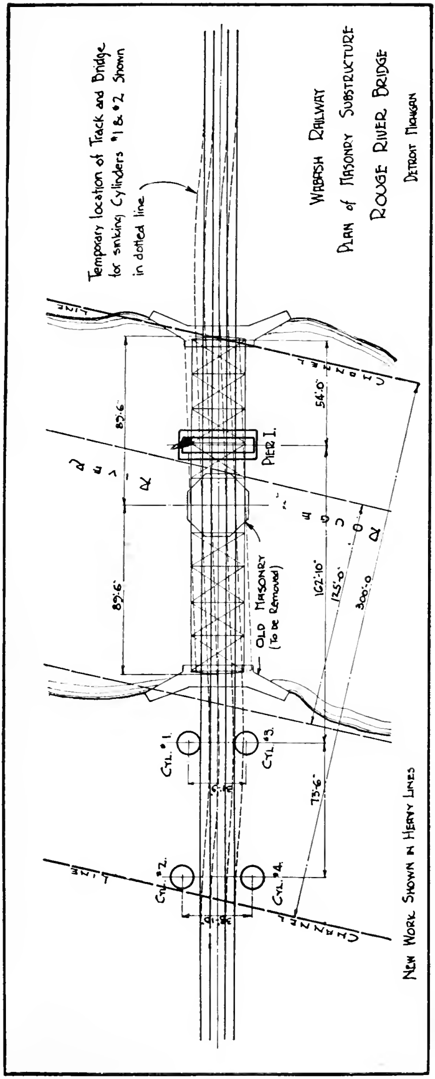

FIGURE 1. PLAN OF MASONRY SUBSTRUCTURE

stream and the Dix Avenue bridge about three-fourths of a mile upstream, and which were found to coincide very nearly. The first 15 feet below the surface is a yellow clay, the next 65 feet is a soft blue clay with varying percentages of sand increasing with the depth. The solid rock, 88 feet below the base of rail, is overlaid with a 6-foot strata of hardpan consisting of gravel and boulders firmly cemented together with hard blue clay.

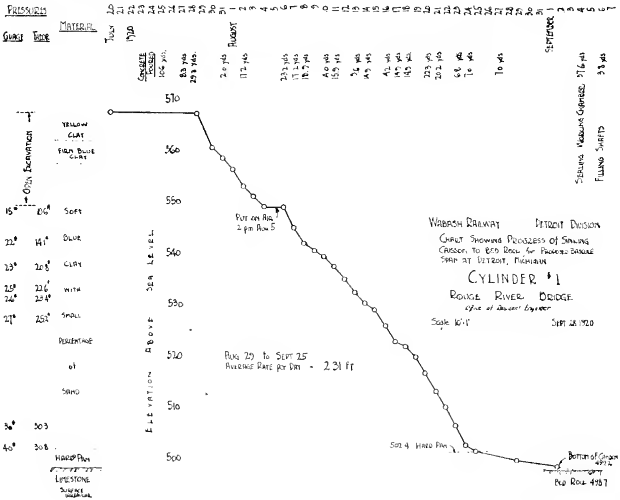

FIGURE 2. CAISSON PROGRESS CHART, CYLINDER NO. 1.

On reaching the top of the hardpan strata, hydrogen-sulphide gas was encountered, and it seemed to occur in pockets. To prevent the gas from entering the working chamber, the pressure was immediately increased from 30 to 40 pounds, which eliminated this difficulty.

CONSTRUCTION OF CYLINDER PIERS

The construction of the cylinder piers was started on July 1, 1920, by building a coffer dam 16 feet square to receive the cutting edge. The distance between the two cylinders nearest the river was 31 feet and 9 inches, which was insufficient clearance to permit two tracks between them. It was finally decided to build the two on the north side first, and shift the tracks

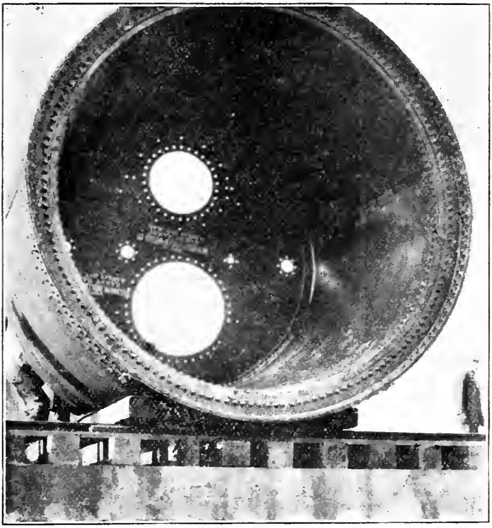

FIGURE 3. WORKING CHAMBER.

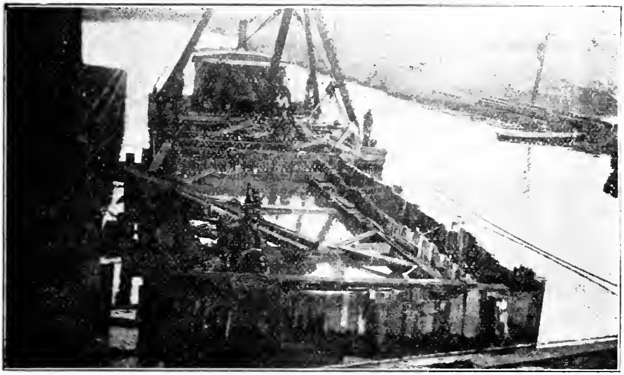

FIGURE 4. COFFER DAM BEFORE UNWATERING.

southerly a distance of 3 feet 6 inches. As the first cylinder was only 38 feet from the end of the draw span, it was necessary to turn the span through a small angle and throw the tracks correspondingly on the far side of the river. While it required considerable labor to make these changes, both mainline tracks were kept in service during the changes.

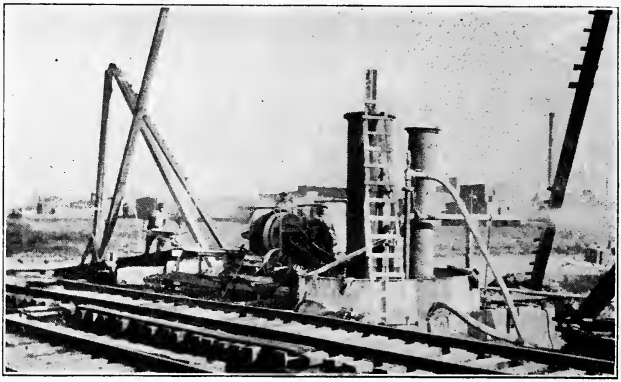

FIGURE 5. GENERAL ARRANGEMENT FOR SINKING CAISSON.

The coffer dam was carried down to a depth of 19 feet, when the cutting edge was lowered in place and the necessary apparatus for sinking was attached. The contractor used the two-shaft arrangement, a 36 inch supply shaft and a 24 inch material shaft, which were attached to the roof of the working chamber. There were also two 4 inch air lines, one 4 inch discharge line and a 2 inch water line. The forms for the cylinders were quadrants of sheet steel, 5 feet in height and bolted together.

The first cylinder was sunk 37.5 feet in the open, excavating the material in buckets through the 36 inch shaft. At this depth, the weight of the cylinder was so great that the friction of the sides would not hold it up to keep the working chamber free, so air pressure was applied, and the material forced out through the discharge pipe. The cylinder went down at an average of 2.31 feet per day until hardpan was reached, and it took about a week to get through the last three feet. When the bed-rock was reached, the remaining boulders that were too large to go out

through the discharge pipes were cleaned off, spread out over the bottom and concreted in.

The sealing process was carried on entirely through the 24 inch shaft. A concrete air lock was bolted on to the top of the shaft, and the door at the bottom opened and removed. The working chamber was then filled by locking charges through the air lock, and the air pressure kept on about 24 hours, till the concrete had received its initial set. Then both of the shafts were filled.

The rate of sinking cylinder No. 1 is shown in the occompanying diagram which is typical of all the cylinders, except for the average rate per day. Cylinder No. 2 went down 3.03 feet per day, No. 3 at 4.32 feet per day, and No. 4 at 4.50 feet per day.

CONSTRUCTION OF THE REST PIER

The dimensions of the shaft of the rest pier are 8 feet by 40 feet in section and 30 feet high. The base is 16 feet by 42 feet and 8 feet in depth all below the bottom of the channel line at elevation 551.5, the bottom of the footings being about 31 feet below the average water level.

A wooden frame of 12x12 timbers in three decks was constructed on shore and launched. Around this frame were driven steel sheet piles 36 feet in length, and as the joints were not watertight, it was necessary to build a puddle wall around the outside of the cofferdam. The material was excavated by means of a clamshell and as the excavation was carried down, the sides were braced with 12x12's to take the external pressure. Toward the bottom, the bracing was insufficient to take care of the excessive pressures and the 12x12's on the south end gave way in the middle. Fortunately, the interlocking of the sheet piling was strong enough so that it did not pull apart, and there were no serious results. The total yardage of the pier was 498 yards.

The work was done by the McMurry Contracting Co., of Kansas City, Mo., under the direction of Mr. A. O. Cunningham, Chief Engineer of the Wabash Railway, and the writer as resident engineer. The total cost of the footings was slightly under $130,000.

A STUDY OF DIRECT CURRENT MOTOR DEFECTS

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This question resolves itself into a study of cause and effect, involving the application of sight and touch in conjunction with the elementary principles of electricity as applied to direct current machines. For the purpose of convenience in this study let us divide all defects, depending upon their origin, into two classes, mechanical defects and electrical defects; however, before proceeding, we must at all times bear in mind that mechanical defects develop into electrical defects and vice versa, so that unless the defect is discovered in its origin we always have a more or less complicated trouble to deal with and the actual seat far removed and hidden.

Mechanical defects

- Commutator
  - high bars
  - low bars
  - flat spots
  - high mica
  - eccentric
  - loose commutator
- Bearings
  - too tight
  - too loose
  - too rough
  - improperly set
  - defective lubrication
- Brushes
  - improperly spaced
  - too much tension
  - too little tension
  - improperly fitted
  - improper quality

Electrical defects

- Armature
  - open circuit coil
  - short circuit coil
  - short between coils
  - grounded coil
- Commutator
  - shorted bars
  - grounded bars
  - oil soaked
- Fields
  - open shunt field
  - shorted shunt field
  - grounded shunt field
  - open, grounded and shorted series field
  - "bucking fields"
- Grounded brush holders

MECHANICAL DEFECTS

The mechanical defects of commutators cause sparking in proportion to the amount of load imposed upon the motor, and this occurs when the uneven portion is at the point of commutation, i. e., at the brushes, because this defective part or "bump" interrupts and interferes with the regular flow of the current between the brushes and the commutator. This sparking will burn and blacken these spots and quickly wear down the brushes; if continued heat will result, sufficient to unsolder the armature leads at these points, thus causing a partial or complete open circuit in the armature coil with all the attendant troubles explained further along.

High bars, low bars and flat spots usually occur in a loosely assembled commutator or result from rough handling; therefore it is advisable to test the tightness of a commutator by rapping carefully all around with a light hammer before turning down a commutator and if necessary take up on the bolts or screws that hold the commutator together. However flat spots are often caused by non-uniformity in thickness and hardness of the mica between bars or by a different degree of hardness in the bars themselves; another frequent source of "flats" is the heavy arc or flash under one or more brushes when the motor is started too quickly, or when some brush makes poor contact with the commutator, starting with a "burn" which develops into a "flat" which can be cured only by truing up in a lathe.

The above defects cause a chattering of the brushes, accompanied by noise, and upon stopping the motor the trouble can be located by feeling for the rough or uneven spots that appear burnt and discolored darker than the rest of the surface.

High mica between bars is caused by the copper wearing away faster than the mica, either because the mica is harder than usual or is too thick, or because the copper is soft; and sometimes, too, because the brushes have not been properly selected for the particular case. The sparking from high mica is continuous at all brushes, causes the entire commutator to overheat and discolor and if the load is heavy sufficient heat will develop to unsolder part or all of the armature leads, throwing out the solder and ending in a shutdown. The use of hard and abrasive brushes will tend to eliminate most high mica troubles, but on account of the tendency to wear down the copper at the same time, most

motor manufacturers today have resorted to the practice of "undercutting" their commutators, so that the mica is slightly below the surface of the commutator segments. This practice is the best cure for high mica and works out especially well where the mica is not too thin and where the motor speed or commutator travel is high so that dirt will be thrown out and not remain between the bars to cause "shorts." Of course, this undercutting must be continued throughout the life of the motor when once started since it is obvious that the commutator could not wear down to a perfect surface; for this reason many large companies operating direct current motors keep a force of men continually undercutting the commutators in order to keep them in good condition.

An eccentric commutator occurs when a commutator is turned down on a bad or misplaced center and will cause more or less sparking, depending upon the speed of the motor. In a slow speed motor the brushes may be able to follow the surface and even in a high speed motor the attendant sparking may be eliminated by increasing the brush tension until the motor can be shut down and the commutator properly trued.

Commutators sometimes become loose, since in the smaller sizes and even up to 25 horse power, they are pressed on the shaft under different degrees of tightness. Under such circumstances the armature leads show a tendency to break where they enter the commutator segment even though the relative movement between the winding and the commutator be very slight. The use of one or more machine screws between the armature shaft and the commutator shell, thus acting in the capacity of a commutator key (such as used in all large machines), will cure a loose commutator.

The brushes convey the current from the line to the commutator; naturally they must present a full smooth surface at all times on their bearing side; the pressure must be even and constant, sufficient to carry the current and yet not so great as to cause undue friction, heating and commutator wear. Therefore, it is important that the brush fit the holder, not so tight as to bind nor so loose as to allow the brush to "jiggle." Brushes that "jiggle" cannot be accurately "ground in" or fitted, which makes it doubly important to obtain a brush that fits the holder on all sides before proceeding to "grind in" the brush.

Sometimes one brush will emit heavy sparking or flashing, this usually being due to an absence of tension on the brush, and sometimes the brush is stuck in the holder, which amounts to the same thing. Pressing on the brush while in operation will usually show up this trouble which is remedied by cleaning or fitting the brush after stopping the motor.

When brushes in adjacent brush holders are not 180 degrees apart electrically, sparking will result at that brush or brushes out of the neutral or commutating position. Shifting the brush holder yoke merely changes the sparking from one set of brushes to the other set. This fault was very common in the older type of motors where the swivel brush holder was used, since the spacing would change with the unequal wearing of the brushes, a defect eliminated with the present box type holder. However, with all types of holders this spacing depends on the distance from the holder stud to the commutator and likewise on the distance from the holder to the commutator; and with modern motors having very short length between pole tips, introducing a narrow area of commutation, a slight misplacement of brushes will cause severe sparking.

Improper position or setting of brushes will cause all the brushes to spark; the coil being commutated must be in a neutral field, the two sides of the coil located between pole tips. Most manufacturers today swing the armature coil leads so that the brushes are in the center of the poles, since this allows easy access to the brushes in a two-pole motor, where the poles are on each side horizontally; and on a four-pole motor where the winding is almost always wave connected, each armature coil lead is swung one-eighth of a circle in opposite directions, also making the brush fall under the center of the pole. However, by carefully adjusting the brush holder yoke while the motor is under operation this neutral point can usually be determined.

The brush position in the modern motor is practically the same for all loads since the influence of armature reaction is almost eliminated by the present high flux densities of laminated poles, steel frames and interpoles. In fact, many interpole motors burn out without exhibiting the usual warning signs of sparking, which is usually the only indication of trouble.

Most brushes today carry shunts, a flexible copper wire that conveys the current from the brush holder or stud to the brush

itself, thus eliminating the danger of having this current travel through the spring, thereby removing its temper and strength, and in addition brushes are usually copperplated, which protects the brush from wearing and gives it better electrical contact with the holder.

Bearings that are tight will heat up and bind, thereby imposing extra load upon the motor and in small sized motors the armature may become so overheated as to burn out. In all sizes the excessive heat will usually cause the bearing metal to melt if babbit or white alloy is the material, while it will stick or "freeze" if the bearing is brass or bronze. At the same time the shaft is generally scored and roughened when a bearing of bronze "freezes," and this is the main argument in favor of the alloy metals now so popular in all sizes of motors. Once a bearing begins to heat due to tightness or roughness of the shaft there is usually no remedy except to fit the bearing accurately or remove the cause of the extra friction resulting in heat. However, in case the trouble is due to a lack of oil sufficient to reach the oil rings, the addition of oil will relieve the cause, provided no cutting has occurred and also by taking the belt off at once, the chances of saving the bearing are increased.

In many cases rings become clogged by dirt in the oil well, or become bent or lop-sided, or pinched in the bearing groove and sometimes jump out on top of the bearing; and if the bearing ring slot is not exactly on top, the ring may drag or catch on the sides—all these conditions which prevent the ring from functioning will soon cause bearing trouble if not quickly located and remedied. Another less frequent trouble is the armature end thrust resulting from the incorrect placement of the bearings, thus preventing the armature from floating in its field, and also causing the brushes to ride too far in or out on the commutator; this end thrust will generate heat at the shoulder on the armature shaft and cannot be cured except by shifting the bearings to allow the armature to float freely. Even the pressure caused by the set screw which usually holds the bearing in its proper place can prove troublesome if it is too long and presses against the bottom of the hole drilled for it in the bearing.

Where it is found that bearings quickly become worn and loose without overheating it is usually caused by excessive belt tension which may be necessary where the area of the motor pulley is too

small for the work it has to perform; if the diameters of both the motor and driven pulleys cannot be increased it is advisable to use a slower speed motor or cover the pulley on the motor with an anti-slipping surface that will permit a looser belt. In cases of vertical drives it may be advisable to install some form of an idler to relieve a bad situation.

A good bearing must be smooth and true, with oil grooves leading from the ring slots to each end of the bearing, connecting there to a groove encircling the bearing on the inside near each end, a hole being drilled through the bottom side of the groove to allow the oil to return to the well below. The shaft should be smooth and true in order that the pull on the shaft be evenly distributed over a large area; the shaft shall have oil throwing ridges located just inside the bearing housing that will prevent the creeping of oil along the shaft, thereby not only increasing the likelihood of lack of oil but also causing much trouble by its presence on the commutator, a point that will be explained farther along.

A worn bearing which will allow the armature to strike or rub against the pole pieces introduces trouble of the worst type; a knocking sound can usually be heard and felt, sparking results from the ensuing overload the temperature rises not only from the excessive current which may burn out armature and series field, but also from the mechanical friction. Upon removing the belt the bearing may be tested for wear, it usually being found that the wear is in the same direction as the belt pull or pressure; upon removing the armature it will appear polished on the end corresponding to the worn bearing and frequently the slot sticks and wedges are charred and burnt even though the winding has not been damaged. Under such circumstances it is well to replace such sticks and fit a new bearing before continuing operation of motor.

One of the most troublesome lubricating ills is caused by the suction created by the ventilating fan or spider put on the armature inside the pulley end bracket in modern motors. This fan can suck the oil through the small space around the shaft, especially when the bearing is worn and this space enlarged, the oil reappearing on the inside of the motor frame, thrown there by the fan in spite of the oil throwers on the shaft. In some cases a heavier grade of oil is necessary or the application of a

felt washer between the bearing and the inside of the housing fitting snugly to the shaft.

ELECTRICAL DEFECTS

An armature coil is called "open circuited" when it is totally or partially opened, either in the coil itself or at its connection to the commutator; in most machines this open or break is usually at the commutator or in the lead just back of the commutator, but in small motors where the wire is small, and therefore weaker, the open may be in the coil itself or on the back end. This open circuit causes the mica to burn away between those bars of the commutator which are attached to the terminals of the defective coil, so that in a lap connected armature (where the coil terminals connect to adjacent bars) the mica is burnt away at one point only, while in a wave connected armature (where the coil terminals connect to bars 180 degrees electrically apart) there will be two such burnt points corresponding to the terminals of the coil. If the open is complete there will be severe flashing, especially under loaded conditions, whenever this open point leaves the brush and the power and thus the speed of the motor will diminish especially in lap wound armatures; continued operation will usually cause this burnt mica to develop into a "short" circuit where the mica is rather thin, or to burn the mica and copper down into a deep groove necessitating in small motors a replacement of the bars and even the entire commutator in exceptional cases.

A "short circuited" coil may be either "dead" shorted or partially shorted by the breaking down of the insulation between two adjacent commutator bars and also the insulation between the turns of the coil itself sometimes breaks down resulting in a shorted coil; in both cases the shorted coil will heat up to a degree depending upon the amount of current induced in the coil, so that in such cases the coil quickly becomes hot even when there is no load on the motor since we have a more or less closed loop revolving through a magnetic field. The odor and smoke of burning cotton insulation is present and if the cause is not removed the coil becomes burnt out and in so doing frequently scorches and ruins the other coil in the same slot and those crossed by it, usually requiring an entire rewind.

Sometimes the insulation breaks down between the armature coils themselves, usually between the top and bottom coils in

the same slot where the coils have been pounded too hard and fit very tightly; in such cases the current will take the easiest path and instead of flowing through all the coils equally on both sides of the armature it will select the short path where the insulation has failed so that when the terminals of these coils arrive at the brushes the armature will have a tendency to lock itself at that point and blow the fuses; where the insulation has not completely broken down the armature will rotate with a slow jerky motion, possess very little power and flash severely. The burnt commutator bars will indicate the position of the defective coils which must be removed from the slot; as a rule they must be replaced with new coils unless the defect has not damaged the coils beyond repair, while in severe cases the entire armature must be rewound.

A "grounded" coil in the armature may not affect the operation of the armature where the frame of the motor is not grounded also. However in many cities ordinances have been passed that require electrical machinery frames to be grounded, and since most direct current systems are 3 wire with grounded neutrals, a grounded armature will draw an excessive current, causing sparking, heating and fuse blowing depending upon the degree of the ground. Most grounds are located at the end of the slot where the insulation has been damaged or cracked by forcing the coil in position, if the trouble has not progressed too far the coil may be carefully lifted and the insulation repaired.

Shorted commutator bars may be due to the insulating mica itself containing bad spots or to copper bridging the mica especially where it is thin; sometimes the accumulation of oil or dirt, either between commutator bars or the commutator necks will cause this trouble; undercut commutators where the mica is very thin is a source of much trouble of this nature especially in locations of much dust and in slow speed machines; not only does this defect cause the coils connected to the shorted bars to become heated but in addition the bars themselves become hot and in many cases to a degree sufficient to unsolder the connections of the coils, causing partial or complete open circuit conditions; also this heat causes the bars to expand and squeeze themselves out so as to result in high bars, which are discolored from the heat. Short circuited commutator bars are probably the most frequent source of burnt out coils and armatures, especially in medium and small sized machines; therefore it is very

necessary to replace and repair the insulation between bars as soon as such defect is noticed; where the defect is on the surface it may be cleaned out for temporary operation until such a time when it can be properly completed.

In slow speed machines it sometimes happens that oil creeps up on the commutator thus introducing a condition favorable for many commutator troubles by the action on the mica and the brushes; an oil soaked commutator will usually run hot all around being more or less shorted by the oily mixture on and in the insulation; in some cases it can be effectively baked out in an oven or by a torch, but in bad cases it must be taken apart and the insulation thoroughly cleaned or better, renewed.

Commutators are usually grounded in the front end where dirt and oil have had an opportunity to affect the insulation: sometimes, however, it occurs in the back under the coil terminals where the solder has fallen during the construction of the machine; the effect is not apparent unless the motor operates on a 3 wire system with frame grounded to neutral, while with such a condition the motor will draw excessive current depending upon the degree of the ground with consequent overheating and sparking and in every case the commutator will flash badly and burn at the point of defect.

A shunt wound motor with an open field will stop, and blow the fuse, or if the load is very light or is entirely removed, it will increase in speed to a dangerous point and possibly break the armature coil bands and throw out the coils with disastrous results; if the motor is compound wound it usually continues to operate with an excessive current, and if the fuses do not protect the motor the latter will quickly heat up and burn out both compound fields and armature; sometimes in smaller motors where the shunt and compound fields are taped together with very little insulation between them, both shunt and compound windings are burnt out from the excessive heat. The open field must be located by individual test and if it is not on the surface of the coil it must be rewound and spliced at the break; defects of this nature are usually caused by winding too tight in the coil or from shaping the coil to fit the field poles, and when one considers that the shunt field is very fine wire(approximating No. 30 in a 1-4 horse power, 220 volt motor up to

No. 20 in a 10 horse power motor of the same voltage) it necessitates care in the handling of such work.

A shunt field more or less shorted on itself will be a weak field since the current does not traverse all of the turns, resulting in sparking at the brushes at that pole and also increase in temperature of the armature especially when the field is very weak; in addition the temperature of the defective field will either decrease or remain constant while the temperature of the other good fields will raise to a noticeable degree so there is usually very little trouble in locating the bad field which must be removed for repair or replacement. If this defect is not located and repaired, it frequently happens that all the good fields are likewise burnt out from the excess of current due to part of the field circuit being shorted thus reducing the total field resistance. A shorted field is usually caused by carelessness in winding the coil when the turns cross each other instead of being in smooth layers; sometimes at the corners in square coils where the wire is tightly packed or pinched; and frequently in certain types of machines where the oil has a tendency to accumulate the bottom fields become oil soaked, rotting the insulation which requires a new field. In some cases a shorted field may burn itself into an open field of an intermittent character which is rather puzzling since the motor will operate apparently very well at times and then suddenly increase its speed for a short time without warning.

A grounded shunt field will cause various symptoms; in a 220 volt motor on a 3 wire grounded system with grounded motor frame those fields on each side of the ground will be subjected to 110 volts, so that some of the fields will be cooler and others will be hotter than their normal temperature, depending on the location of the ground. As a rule sparking results from the unequal field strengths and the motor changes speed and the armature rises in temperature; in a 110 volt motor operating on a similar system these fields between the neutral and the ground will carry no current, while those fields between the defect and the outside wire will thus become overheated from the rise in current, resulting in sparking and burning out of those overheated fields if not remedied. In a 110 or 220 volt motor with insulated frame a grounded shunt field does not affect the operation until it develops into a short or an open field as usually happens.

A grounded series field will remain unnoticed in an insulated motor frame, but in a grounded frame on a 3 wire grounded system the effect is similar to that produced by a grounded commutator or armature, drawing an excessive current, heating up the series field and armature and blowing fuses.

When a shunt field is shorted on a series field those shunt coils located between the point of defect and the regular connection of shunt and series fields will carry very low currents, being shunted across part of the series winding, while those coils on the other side of the defect will overheat. At the same time serious sparking and overheating of the armature results with damaging consequences unless the trouble is located and repaired by removal of the fields.

Sometimes a motor will have one of the series fields opposing the shunt field on the same pole and may operate fairly well providing the load is under the rated capacity of the machine, but as a rule sparking will be present and be rather severe under heavy loads. A test using a compass with the separate windings will locate such a defect. More often,, however, a motor is incorrectly connected in backwards so that it opposes the shunt field, resulting in a weakened field with consequent sparking and overheating of the armature from the excessive current. By running the motor as a series motor for an instant to ascertain the direction of rotation, and then try it as a shunt motor, noting the direction of rotation, you can quickly test for opposing or "bucking" fields, since the motor will rotate in opposite directions if the fields are "bucking" each other.

The action of oil and dirt and sometimes careless handling will cause a grounded brush holder, resulting in trouble similar to that experienced from a grounded commutator; porous insulating materials used for the support of the brush holder studs usually cause the trouble and should be replaced with hard fiber or bakelite or similar materials when repairs are made.

In conclusion it may be added that most motor defects will cause the machine to drop in speed, spark and rise in temperature, field defects as explained may cause an increase in speed depending upon the load and location of the trouble. By careful observance of the condition of the commutator, the nature of the sparking and its results on the commutator, by removing the belt or load and testing the bearings, together with the temperature of

the armature, fields and commutator, it is possible to ascertain and locate a large majority of motor troubles, possibly 90 per cent, by means of a test lamp.

Most motor troubles start at the commutator and at least 90 per cent of all motor troubles are located in the armature and bearings; comparatively speaking, the fields give only a small percentage of the defects; yet at all times we must bear in mind that a defect in one place will quickly grow into a complicated trouble involving many other parts so that in most cases we cannot state for a certainty the exact origin or seat of the trouble.

WORK RESUMED ON TUGALOO RIVER PLANT

The hydro-electric power development of the Georgia Railway and Power Company on the Tallulah and Tugaloo rivers will now be completed, as construction work is to be resumed shortly after a lapse of some three years caused by war-time conditions. The development was started about three years ago. At that time the water-wheels and electric equipment were ordered, and most of this equipment is now installed or ready for shipment.

The dam will be 124 ft. high, 130 ft. thick at the base, and 850 ft. long at the top. The plant will be equipped with four 22,000-hp. water-wheels driving vertical 6,600-volt generators. There will also be an auxiliary unit of 1,000 hp. for plant use. Power will be transmitted to Atlanta and other points at 110,000 volts.

The Armour Engineer

The Quarterly Technical Publication of the

Armour Institute of Technology

VOLUME XIII | MAY, 1922 | NO. 4

Published four times a year, in November, January, March and May. Publication Office: Federal and 33rd Streets, Chicago.

TERMS OF SUBSCRIPTION.

The Armour Engineer, four issues,postage prepaid, $1.50 per annum
Single copies, 45 cents.

THE ENGINEER IN INDUSTRIAL LIFE

The first few years out of college are likely to be full of exercise of mind. The world then seems especially large and the graduate very small. With most of us it is hard to know where to start.

But to get started is important. Whatever it is you start at, put into it that gift of youth—plenty of "Interest"—and get as thoroughly into your work as possible. Go to the bottom of it. Only in that way can you honestly determine if you are meant for it and it for you.

If the first work proves, after a fair trial, to be uncongenial, change to something else. Don't be afraid to change connections.

As long as you go to the heart of each experience the only way to find yourself is to try different lines. Nobody respects a fly-by-night, nor on the other hand is it any longer a virtue to tie to one company for a life-time if you are to develop into an experienced engineer, executive, or business man.

Of course, as far as possible, not only should you make each move count but there should be a constructive progress in your change of connection. It may not be superficially evident but it should be discerned in your own mind. Real self respect dictates that you care for your own life and how it is spent and the inner advance made.

Someone has advised—"Choose your own boss." Connections should be as carefully chosen as circumstances and conditions in business allow. A record of connections with outstanding companies, whether large or small, speaks volumes for you as you get along. And the most important thing in any company is the size and type of man you work for.

Sometimes you will find work with a good but small company has far more opportunities than that in a great corporation. Small concerns do not carry specialization so far and therefore offer more educative opportunities in the first few years out of college. Your experience should not be confined to small companies because you will not be fitted for the size and perspective of great operations.

In the process, while you are deeply interested and absorbed in your work, look to keeping yourself balanced. Good reading and the right contacts keep imagination open and free. Next to imagination a sense of humor is most important because it develops poise and an understanding of men. If you haven't a positive humor you can at least sustain an appreciative sense. If you find the right girl get married—the earlier the better. A good partner at home is a gift of the Gods.

Engineering training and experience offer a splendid background for the making of executives. If, to be a Manufacturing Executive is your objective, it is important that you study organization and planning, gather some knowledge of factory and general accounting and of the relations of the other divisions to finance. This makes for rounded executives, and they are very scarce.

Too much outward reward may be positively dangerous in the

first few years out of college. Conditions together with self discipline should bring self knowledge. Inner recognition is the great thing, or—Finding One's Self.

Wm. Robt. Wilson, '06, M. E. '11.
President, Maxwell Motor Corporation,
Chalmers Motor Corporation
Detroit, Michigan.

A REMINISCENCE.

In every institution's formative period rapid changes take place not only in personnel but also on the material side. Armour Institute of Technology has been no exception to this rule. Aside from the buildings themselves, one who last saw the college in the middle nineties would scarcely recognize it were he to return now. Probably more changes both in location and equipment have taken place in the Dynamo Laboratory than in any part of the Institute. In the spring of 1894, when the writer became a member of the Electrical Department Faculty, the entire equipment of dynamo electric machinery was located in the present sophomore laboratory and consisted of four machines each with a capacity of about 3.5kw. The switchboard consisted of a wooden frame equipped with arc light circuit spring jacks and plugs. A supply of flexible cables was on hand obtained from the electric launches operated at the Wooded Island during the World's Fair. Many of these cables are still in daily use in the laboratories at the present day. Using these machines and those composing the power plant as an equipment, the writer taught night school (later discontinued) in electricity and in steam engine operation and valve setting in the spring of 1894. The students were mostly engineers from the steam-driven south side elevated road. Inspection visits were made to the Washington Park arc station, the Commonwealth Edison station at Washington Street and the river, to Fifty-third and State Street, and many other places which are now only a memory.

The purchase of the real dynamo laboratory equipment, however, was officially begun by the purchase of a 30 h.p. motor and two Thomson-Houston arc machines in 1896. These were tandem driven and were located in the old engine room just where the smokestack now stands. To the south of it was the Corliss engine furnishing power to drive the electric power equipment of the

Institute. A rope drive from this engine operated a jack shaft located in the west end of the room from which two generators, both alternators, were belted. One of these was a 1100 volt single-phase Westinghouse alternator and the other was a National. The former is now in the dynamo laboratory and the latter was replaced by a 60 kw. C. & C. generator then by a 100 kw. Western Electric and finally by one of 200 kw. capacity. The writer in 1912 saw this old Corliss engine at Fulton, Ky., where it had been doing duty in the municipal plant and was just being replaced by more modern machinery.

From the old engine room the equipment was moved in 1897 to the basement of the Mission in order to make room for the installation of one of the experimental steam engines now located in the present engine room. The new location in the Mission was one now occupied by the Institute carpenters, this room was so small that there was scarcely place for more than the machines themselves and in pleasant weather the tables, on which the instruments were connected, were sometimes placed outside on the sidewalk with cables extending through the open door.

The next location was in the room now occupied by the receiving office in the northwest corner of the Mission basement in 1898-9. These quarters were so much larger that it seemed nothing further could be desired. This move was made because of the danger of using machinery in such cramped quarters. The entrance to the new laboratory was from the lower hall of the Mission. After about two years of location in these quarters, the necessity of finding larger quarters for the Academic Physics laboratory, made another change necessary. A contributing cause of complaint was the noise of the machinery which disturbed the peace of the kindergarten rooms above on the second floor.

From this place the machinery was moved in 1900-1 across the hall to the larger northeast basement room. After two years of occupancy of this room, the new Machinery Hall was built, and the present dynamo laboratory which up to that time had been the machine shop, became vacant and the east half of it was given over to the Electrical Department and in 1903 the dynamo laboratory was moved over into it, the west side was occupied by the lunch room with an eight foot wooden partition between the two. When Ogden Field was purchased and the present lunch room established the dynamo laboratory was allowed to occupy the entire room as at present. The dates given above are approximate only.   Prof. J. E. Snow.

RADIOPHONE BROADCASTING

The art of electrical communication has recently developed a new public utility,—radiophone broadcasting. The tremendous strides made during the World War in perfecting vacuum tube radiophone transmitters has made the wireless transmission of speech a commercial success.

The average citizen, however, was still ignorant of the great possibilities of the new development until the establishment of the modern broadcasting station for supplying daily entertainment and news of general interest. The first real broadcasting station was established in December, 1920, at East Pittsburgh, Pa., and has been in continuous operation every day since. This first station met with such success that today, large broadcasting stations are in operation at Schenectady, New York, Chicago, Springfield, Mass., and Newark, N. J.

Radio broadcasting has a universal appeal to all classes of people and in order to sustain the present popular interest in radio it is necessary that a well-rounded daily program of entertainment be sent from these stations. The daily newspapers are largely responsible for the present phenomenal interest in radio. Many of the large dailies have special radio sections and some even publish a week-end radio supplement. The newspapers are also publishing the daily broadcasting program of the nearest radio station. Through this widespread publicity, interest in radio has reached such proportions, that the song writers and theatrical men have become alarmed lest their incomes be suddenly cut off.

Trade reports indicate that many experienced business men are freely investing their own capital in various radio manufacturing enterprises in the firm belief that amateur radio is a permanent and growing industry. At the present time there is an acute shortage of radio parts and complete receiving apparatus, but manufacturing facilities are being increased to take care of the demand. If the demand for radio apparatus should fall off in the near future, it will probably lead to severe price competition, due to overproduction.

If radiophone broadcasting becomes a permanent utility it will offer many opportunities to the engineer in the design, manufacture or sale of the necessary apparatus.

ENGINEERING SOCIETIES

THE ARMOUR TECH STUDENT BRANCH OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

The past year has been one of unprecedented activitiy and accomplishment for the A. S. M. E. Never before has the attendance and interest displayed at the many meetings beer equal to this year's record. Co-operation between our branch and the Chicago local branch has been discussed for years but has not been brought about until this year when three or four student members addressed a meeting of the local chapter.

The following excerpts from a leaflet published by the parent organization are published for the benefit of the members:

"A Junior member shall be 21 years of age or over. He must have such engineering experience as will enable him to fill a subordinate position in engineering work, or he must be a graduate of an engineering school.

"The initiation fee for Juniors is $15, and the dues are $10 for the first six years. If a Junior has been promoted to another grade at the end of six years his dues advance to $15, which is the same for all other members.

"Graduates who apply for membership immediately upon election will be called upon to pay $15 initiation fee and only that portion of the year's dues dating from their election to the first of October following. In most cases this will be about two months, or $1.66.

"The student has the opportunity for developing in the art of presenting orally, engineering matter before an audience; speaking extemporaneously and stating a proposition clearly and convincingly. The student members have the privilege of subscribing to the A. S. M. E. Journal at member's rate of $2.00 per year and using the advertising department, the Mail Service Library and of submitting articles to be published should their merit warrant such. Upon graduation there is the privilege of limited member-

ship without expense and becoming eligible as a Junior member of the Am. Soc. M. E.

"Members of Student Branches upon graduation will be enrolled as members of the Local Section in any city they want to go to without payment of any kind outside of their dues in the Student Branches. The A. S. M. E. pays their dues in the Local Section with a view to assist graduates in getting acquainted and to enable them without financial burden to secure benefits of the technical meetings in whatever city they may obtain employment. It is necessary only for the graduate to advise the Secretary of the A. S. M. E. at the New York headquarters of their new address, and the company where he is employed."

We wish to express our hearty thanks to Professor Gebhardt and his faculty in appreciation of their most welcome support extended to this organization from time to time throughout the year.

David S. Jennings, Secretary.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

As the semester rapidly draws to an end the Armour Branch of the A. I. E. E. can proudly state that it has passed through a very successful year. The society can boast of an active membership of sixty men, all of whom have shown an intense interest in the affairs of the organization.

At the regular meeting of March 3, the men were addressed by Professor N. Lesser on the subject of "Furnaces." The speaker described the various types of commercial furnaces in use today, such as: gas, fuel oil, and electric induction. He also pointed out the various conditions that must be met in the design and construction of an industrial furnace, in order to secure best results with minimum up-keep expense. Some practical problems that came up in the building of an annealing furnace for armature punchings, in the plant of a large electrical manufacturer, were very clearly explained.

On March 31 a joint meeting of the A. I. E. E. and A. S. M. E. was held in Science Hall to hear an address by Mr. V. H. Tousley, chief of the Electrical Inspection Department, City of Chicago. Mr. Tousley covered his subject, "The Importance of Electrical Inspection," in a very thorough and interesting manner. Being an old Armour man (Class of '97) the speaker made fre-

quent references to his college days and managed to hold the undivided attention of all his auditors during the one-hour period. He gave a vivid description of the famous Iroquois Theater fire which was indirectly caused by faulty methods of stage lighting. The speaker also cited some instances where electrical inspection had saved human life and pointed out in particular that the work of electrical inspection has reduced materially the number of fires whose origin can be traced to faulty electrical installations. Several slides were shown which vividly illustrated the tremendous development made during the last twenty years in the design of fuses, fuse boxes, sockets, and iron pipe conduit.

The enthusiastic manner in which the Juniors have participated in "talks" during the present year, predicts a very successful A. I. E. E. program next fall.

L. E. Grube, Secretary.

FIRE PROTECTION ENGINEERING SOCIETY

The F. P. E. S. was carefully reorganized in 1920 from the "smoldering embers" of many past years. The department grew so rapidly in numbers in 1920-21 that it was deemed necessary to organize a representative society of the department, to keep our large crew of Sophomores and Freshmen on speaking terms. The heavy burden of all this creative work fell upon the shoulders of the stalwart Seniors, but nevertheless with all their efforts very little was accomplished, the first year of reorganization.

Last semester, however, we started off with a bang and have been going under full steam ever since. The first meeting of the year was a business meeting, a committee being appointed by the president to either draw up or select a suitable constitution for the society.

At the next meeting, a constitution was adopted, after some heated discussion on the part of the Sophomores and Freshmen, because they considered the proposed treasury system inadequate.

There are at the present writing, seventy-two men in our organization, everyone of whom is benefiting himself, by gaining a clearer conception of fire protection engineering. Professor J. B. Finnegan has been successful in securing good speakers for the meetings and in selecting them from various lines of work.

Major Schroeder of the United States Air Service was our

first speaker and although his subject had little bearing on Fire Protection, the Physics Lecture Room was jammed to capacity.

Mr. John Plant of the Bureau of Fire Prevention spoke on "Fire Prevention in the City of Chicago."

Mr. W. C. Geilow, an Armour man in the inspection field, spoke on "The Inspection of Ordinary Risks."

Mr. Arthur Jens, also an Armour man and head of the Engineering Department of Fred S. James & Co., Chicago, gave a non-technical talk on "Things We Know But Don't Think Much About." He stressed the importance of the "humanities" in a college curriculum and also touched upon such personal matters as: health, appearance, loyalty and enthusiasm.

On March 31 Mr. Clarence Goldsmith, Engineer, National Board of Fire Underwriters, gave a splendid talk on the purposes and functions of the National Board.

The Fire Protection Engineers of A. I. T. were slow in getting started because of the set back received during the war, but now we can boast of an organization as active as any of the other engineering societies at Armour.

Robert Reginald Maguire, Secretary.

ARMOUR CHEMICAL ENGINEERING SOCIETY

On the evening of March 9 the Armour Chemical Engineering Society gave their annual smoker in the rooms of the Y. M. C. A. in Chapin Hall. The affair was well attended, probably (?) due to the customary smokes and Eskimo pies. The evening's program was a big success, however, by reason of the talks given by members of the faculty and especially by our guest for the evening, Mr. L. K. Wilson, superintendent of the National Lead Company. His talk was informal and of the heart-to-heart type—the kind that could not fail in its purpose. Mr. Wilson chose to speak on a subject very appropriate at this time of the year, namely, "Getting a job." He outlined certain "do's" and "don'ts" and interpolated many valuable suggestions. Those present drank in every word and at the conclusion of the talk expressed their appreciation for the many opportune suggestions. His talk certainly put the task of "getting a job" in a new and more favorable aspect.

The next meeting of the Society was held on March 24. Due to his illness, Professor C. A. Tibbals was unable to address the Society at this meeting. It was unfortunate that the members could not hear his especially prepared address, but we hope to listen to it later on at some future meeting. Professor H. McCormack substituted for Professor Tibbals at this meeting and did so in excellent fashion. Although called upon at the last minute, he came to bat with a very interesting paper on "The Dependence of the World On the Chemical Industries." He showed very clearly the paramount importance of the chemical industries and left us with the idea that the chemical industries are no less important in times of peace than they are in times of war.

The Armour Chemical Engineering Society and the other technical societies at the Institute held a joint meeting in the Assembly Hall of the Armour Mission on April 21. The speaker on this occasion was Mr. E. S. Hall. He addressed the societies on "The Ethics of Engineering."

On April 28, Dr. Ross A. Gortner, Professor of Agricultural Bio-Chemistry, at the University of Minnesota, addressed the members of the Society and their guests, the Freshman and Sophomore students of Chemical Engineering. This was a banner event for the Armour Chemical Engineering Society. Dr. Gortner as National President of Phi Lambda Upsilon, the Honorary Chemical Society, is making a tour of the country and by special request he consented to address the Armour Chemical Engineering Society on the subject of "Colloidal Chemistry." His address was excellent and very highly spoken of and referred to by all those who had been fortunate enough to hear him.

J. WARREN McCAFFREY.

WESTERN SOCIETY OF ENGINEERS

The Society held its annual election at the meeting of March 3. The officers for 1922-1923 are: H. W. Munday, president; G. Goedhart, vice-president; T. J. Kauders, secretary; J. Williams, assistant secretary; C. W. Carlson, treasurer.

At the meeting of March 24 Professor Wells gave an illustrated lecture on "The Erection of the Draw Span of the Rock Island Bridge." This lecture brought out many of the difficulties of construction work. It was really a journey from the class

room to the job for forty-five minutes. The lecture was enjoyed by all and particularly by the Juniors and Seniors.

Mr. J. B. Hittell gave an illustrated lecture on "Asphalt and Its Use in Highway Engineering" at the meeting of April 7. This lecture treatd briefly of the origin, occurrence, refining, and properties of asphalt, and the construction of asphalt macadam, asphaltic concrete, sheet asphalt, and asphalt block pavements. Many of the chemical students came in to the lecture. The Society welcomes all engineering students to all the meetings.

The growth of the Society has begun to manifest itself. With such talks as Ethics," by Mr. E. S. Hall; "Essentials of Personal Success," by Mr. T. F. L. Henderson; "The Drainage of Holland," by J. C. Penn, the Society expects to wind up the year.

Professor Penn spent some time in Holland last year, and his talk is being looked forward to with much eagerness. The plans for next year will put the Society in the position it should occupy as an inspiration to all of its members.

J. Williams, Asst. Sec.

COLLEGE NOTES

ASSEMBLIES

Since the last issue of the ENGINEER several very interesting assemblies have taken place. Mr. Frank Rindge addressed the student body on the "Human Side of Engineering," bringing out several important points necessary to the knowledge of a real engineer. Some outstanding statements follow: "The greatest need of America is the right leadership in industry. It must come from the colleges and engineering schools.

"Success in industry depends on Money, Materials, Machinery, Merchandise, Men.

"Commerce depends on Capital.

"Capital depends on Credit.

"Credit depends on Confidence.

"Confidence depends on Character.

"The labor turnover of the United States costs our country from 150-400 millions of dollars per year."

Major R. W. Schroeder of the Underwriters' Laboratories and late of the United States Air Service gave the student body a very interesting two hour illustrated discourse on his experiences while a test pilot in the Army Air Service. His vivid descriptions of his numerous altitude flights ending with his flight when he made the record-breaking altitude of 38,180 feet, held the attention of the entire audience until the end. His pictures of the work of the air service, especially those showing the parachute jumps, together with his descriptions and comments, proved the feature.

At the assembly of April 3 the following men received their "A" sweaters: Capt. Rutishauser, Capt.-elect McLaren, Spaid, Schumacher, May and Johnson. They, with the remaining members of the squad, are certainly to be commended for their spirit, determination and ability shown during the season.

ATHLETICS

BASEBALL

The weather has proved a handicap to our baseball team—it rained practically every day before the first game, so the team

got but little outdoor practice. The first game was played on our diamond with the American College of Physical Education. The game was slow—so slow that the game was called in the eighth inning because of darkness. The score when the game was called was 9-7 against us.

The next game was with Concordia. Our team found themselves for a 10 to 1 victory. The signals were working smoothly and practically every player had hit his stride. The weather again interfered at the time for our games with De Paul and Wisconsin and they had to be called off.

The team embarked on its first trip April 19. The first stop was at DeKalb, Ill., to play DeKalb Normal. This, to quote Eckersall, was a hectic game. Our team pounded out eighteen hits and won, 17-13. The team then jumped to Dubuque, Iowa and played Columbia College there. This game was close, but the team managed to win by playing some real ball. The score was 3-2. This was the first defeat Columbia had received in two years. The last stop was made at Des Moines, Iowa, where Des Moines University was defeated, 13-7. The team returned Saturday, April 20. Again the weather interfered and the Lake Forest game had to be called off. The team is running smoothly and we are not expecting to drop a game. The work of Plocar, our catcher, is very good. Walsh on first is doing his share. Besides coaching, Walsh plays the game. A well known sport writer said that Walsh was one of the best first sackers he had seen playing college ball. Rowe, on second is doing very nicely. His pep means much to the team. Schumacher, our captain handles third base in a clever manner. This is his third year of ball. The outfield is exceptionally good. Walsh is well satisfied with the spirit shown by the players and assures us the team will be a credit to the school. The schedule this year was very creditable. Purdue, Chicago, DePaul, Michigan Aggies, Columbia, etc., make up the type of teams we are playing.

Golf has been started under the temporary supervision of D. R. Hyde. A match will be played with Chicago, May 10, and one will be played with Northwestern later. The team is practicing out at the Windsor Park golf club grounds.

Tennis has also been started and placed under the supervision of J. Warren McCaffrey and J. S. Farrel. A school tournament is being held and a team will be picked from the entrants to repre-

sent the school in matches with Chicago and Northwestern.

Track enthusiasts are working out in an effort to make the team that will be entered in the DePaul Track and Field Meet at Patten Gym., May 19.

INSPECTION TRIPS

The Junior and Senior students in Mechanical Engineering made an all day inspection trip to the Nash Motors Co. of Kenosha, Wis., on March 31st. The Nash plant is unique in that practically all parts of the cars are made in the plant, giving the visitors an excellent example of almost all phases of automobile manufacture.

The Junior and Senior Students in Electrical Engineering, forty-five in number (including three Hydro-Elecs), made an all day inspection trip to Milwaukee on April 13th. The plants of the Cutler-Hammer Co. and the Allis-Chalmers Co. were visited. The extreme variety of work carried on in the latter plant made this visit of especial interest. All phases of the construction of electrical generating and motor apparatus from steel rolling to coil winding were to be seen. Numerous other trips have been held from time to time, places visited including the Hyde Park Exchange of the Chicago Telephone Co., the Automatic Telephone Co. and the Western Union.

READ AND HEED

An assembly was held on Monday, March 27, following the close of the Song and Cheer Contest on March 24. The judges, under the chairmanship of our Prof. Leigh, had decided that they would recommend that the contest period be extended until the opening of the fall term in September, 1922. This because the number and quality of most of the material handed in showed the effects of too much haste, and in the opinion of the committee an extension of the time would certainly tend to the production of more and of better material. The prize money if nothing else should arouse the interest of a number of the alumni and students and result in the composition of some excellent songs.

NEWS NOTES

Acting President Howard M. Raymond is to give the Commencement address at the Commencement of the Colorado School of Mines, Golden, Colo., on May 19th. At this occasion the institution is to confer the Honorary Degree of Doctor of Science upon Prof. Raymond.

Dean Louis C. Monin when last heard from, about March 30, was recovering from a bad attack of influenza at Lake Lagano, Italy. Prof. Monin is expected to return in June.

The Rev. Dr. Frederick F. Shannon of the Central Church of Chicago will give the Baccalaureate sermon at Orchestra Hall on Sunday, May 21.

The Rev. Dr. Newell Dwight Hillis of Brooklyn, N. Y., will give the Commencement address to the Seniors in the Mission on the evening of June 1st.

The Spring Initiation of Tau Beta Pi was held on Saturday, May 6, with the semi-annual banquet on the evening of May 17. The initiation of Eta Kappa Nu was held May 13 with the banquet on May 11.

The Juniors of 1922, following the precedent set by the Seniors of 1922 while they were still classed as lowly Juniors, held their Junior Prom at the Blackstone Hotel with the success which should always attend such a magnificent affair.

REGISTRATION SECOND SEMESTER, 1921-22

	Seniors	Juniors	Sophomores	Freshman	Post Grad.	Specials	Total
Mechanicals	30	47	44	42	..	3	166
Electricals	22	27	46	59	..	1	155
Civils	19	29	38	24	..	..	110
Chemicals	16	16	30	36	..	1	99
F. P. Eng.	3	6	23	24	..	..	56
Architects	13	11	14	18	1	12	68
Industrial Arts	..	..	1	3	..	1	5
Post Graduate	..	..	..	..	1	..	1
Total	103	136	196	206	1	18	660

On Monday, April 17, the election of the officers of the Armour Tech Athletic Association was held. Harold W. Munday was elected president, Edward S. McLaren was chosen first vice-president, George P. Ruddiman was elected secretary and Milton H. Westerberg second vice-president with George S. Allison, comptroller of the school, as treasurer. The spirit displayed at the meeting was exceptional and promises well for a continued athletic support.

THREE MOTIVES

In an inaugural whose title, "Motivation in Education," suggests a technical treatment, which is quite foreign to its style, President Brown of the University of Chattanooga, holds up three motives as desirable in the education of a college student: "A passion for thoroughness in whatever task he undertakes, a passion to discriminate right from wrong, and a passion for unselfish service." Few will deny that such motives, whether operating in or out of college, constitute a formula for successful living. President Brown pointed out certain ways in which the teaching and example of the faculty, and the influence of the extra-curricular activities of the students might be made to foster such motives. But the culmination of his argument was the one which deserves the consideration of every educator. He advocates as a means of development these high motives from which character is built: *"Direct instruction in the materials which historically have been most effective in inspiring the two essential motives."*

INITIATION OF THE FROSH MUST BE EASY AT CORNELL

The students, upon returning from their Christmas vacation, were all sorry to hear of the serious damage to the rolling stock of the Ithaca Traction Company. Due to the cold snap during the vacation the hills were very icy and one of the cars became uncontrollable and slid backwards down the State Street hill crashing into another car. No serious injuries resulted, but the damage to the company's rolling stock is estimated by those well informed as reaching 50 per cent. The other car is still running. It is interesting to note that the runaway car number 33 crashed into car 41, but what's in a number?—Cornell Civil Engineer.

HOW DOES A STUDENT SPEND HIS SPARE TIME?

Some time ago the following questionnaire was circulated among the students:

"The following information is desired for statistical purposes only, and will be held strictly confidential. The blank will be destroyed as soon as results are tabulated.

Approximately what per cent of your living expenses (board and room) do you earn? A..............................

Approximately what per cent of your school expenses (tuition and fees) do you earn? A..............................

What is the nature of the work? A........................

Are you a citizen of this country? A.....................

Name or Registration Number. A.........................

A total of 626 students have answered this questionnaire, practically the entire student body.

The following is the result of this canvass:

Per cent of total	0	0-25	26-50	51-75	76-99	100
Living expenses (board and room)...	344	81	71	19	6	71
School expenses (tuition and fees)....	181	26	77	37	21	221

Nineteen (19) recorded themselves as not being citizens.

Seventy-six (76) worked during the summer months only.

Three hundred and twenty-six (326) worked during the school session and summer.

Eighteen (18) worked during school only.

Nineteen (19) had earned money for school and living expenses before entering the Institute.

One (1) stated that he paid an income tax.

Fifty-five (55) earned all their living and school expenses.

One hundred and thirty-three (133) earned nothing, either towards living or school expenses.

The above figures and results contain the returns from twenty-four Federal Board for Vocational Training Students, whose school and living expenses are paid by the Government, and fifty-four scholarship students, forty-six of whom have their entire school expenses paid for by the Western Actuarial Bureau, and the remainder their tuition only paid by the Institute.

The following gives a partial list of the various jobs held by the students:

Dairy helpers (2), teachers (13), salesmen (49), insurance agent (3), surveyors (5), bookkeepers (6), steel mill workers (5), ushers (2), draftsmen (41), substation operators (4), miners (1), clerks (54), traffic directors on elevated railroad (4), machinists (13), fire insurance inspectors (1), postoffice helpers (11), carriers (1), cab drivers (2), printers (3), farmers (7), baker (1), athletic director in boys' camp (1), auto mechanics (19), radio operators (4), movie operators (3), rating and bureau work (1), carpenter (1), bricklayer (1), janitors (10), oiler on lake boats (1), stenographer (1), chemist (11), gardener (1), life guards (3), magician (1), factory hands (7), cook (1), waiter (2), painters (4), chauffeurs (8), miscellaneous office workers (23), musicians (14), printers (3), map tracing (1), movers (1), switchboard operators (3), athletic work (3), florists (2), electrical work (21), cashiers (1), inspectors (5), testers (1), shop helpers (1), advertising (1), student assistants (20), cloakroom attendant (1), engineer's helper (2), restaurant workers (4), assistants Lee Laboratory (2), delivery (2), mechanical workers (6), miscellaneous workers (38), barber (1), telephone workers (6), shipping room clerks (2), manufacturer (1), real estate (3), social workers (3), firemen (2), linotype operator (1), toolmaker (1), theater (2), ordinary labor (1), lineman (1), timekeeper (1), engineering (6), refrigeration (1), newspaper work (3), farmers (8), ticket agent (1), express work (1), foreman (2), contractor (1), interviewer (1), stewards (3), cabinet makers (1), cleaning and pressing (3), truck driver (1), railroad work (1), boiler maker (3), scout master (1), Y. M. C. A. secretary (1).

During the past semester the scholastic standing of each student of the College of Engineering and Architecture who was in attendance during the first semester of 1921-22 was computed. In this computation the grades in physical training were omitted.

The following numerical values were given to the letter grades:

A—97.5%.	C—80%.	E—50%.
B—90%.	D—67.5%.	

The average of the entire school body (720 students) is 85.59%.

The average of the various organizations are as follows:

The Senior Class—89.2%.
Junior Class—87.1%.
Sophomore Class—85.9%.
Freshman Class—83.3%.

Students in—

Mechanical Engineering	86.3
Electrical Engineering	85.9
Civil Engineering	85.7
Chemical Engineering	86.7
Fire Protection Engineering	85.3
Architecture	81.9
Industrial Arts	84.0

Honorary Fraternities—

Tau Beta Pi	92.2
Eta Kappa Nu	90.9
Phi Lambda Upsilon	91.0

Social Fraternities and Clubs—

Phi Kappa Sigma	84.9
Delta Tau Delta	85.8
Sigma Kappa Delta	85.7
Omega Lambda (now Theta Xi)	85.7
Beta Phi	83.7
Sigma Alpha Mu	87.8
Rho Delta Rho	87.7
The Pyramid	88.4
Scroll and Triangle	88.2

The highest individual records are—

Senior..H. W. Herbst	94.6
Junior—E. A. Arentz	94.6
Sophomore—H. Solomon	95.2
Freshman—M. F. Adair	95.3

The average of all students belonging to the Phi Kappa Sigma, Delta Tau Delta, Sigma Kappa Delta, Theta Xi, Beta Phi, Sigma Alpha Mu, and Rho Delta Rho fraternities is 85.6 per cent.

The average of all students other than those in the above mentioned fraternities is 85.6 per cent.

It is rather remarkable that fraternity men and non-fraternity men have the same average.

THE ALUMNUS

Being That Part of **The Armour Engineer** Devoted to Personal Mention of the Graduates of the Armour Institute of Technology and to the Affairs of the Armour Alumni Association.

W. J. Bentley, Armour Institute of Technology, Chicago, Ill.

Officers of the Armour Alumni Association for 1921-22.

W. A. Kellner, '10.................. President
Raymond J. Koch, '13. .... Vice-President
Howard S. White '17............... Treasurer
Walter H. Hallstein '14.....Recording Secretary
Walter J. Bentley '20..Corresponding Secretary
Morris W. Lee '99.......Master of Ceremonies

Board of Managers.

Retiring 1922	Retiring 1923	Retiring 1924
R. M. Henderson '02	C. A. Knuepfer '15	W. D. Matthews '99
J. C. Penn '05	F. C. Dierking '12	Wm. H. Long '02
B. S. Carr '15	Sidney V. James '07	M. A. Smith '10

THE YEAR

When the officers of the Alumni Association surveyed the field of their work last September they found a great deal of the Armour spirit and enthusiasm had been left undeveloped and that many new projects were open to the Association.

During the year the Officers and Board of Managers held meetings which have averaged two a month. A careful analysis of the records of the Association was made and many of the older men were called on for their advice. It was apparent that the following defects were hampering the Association:

1. The Semi-yearly meetings did not provide sufficient contact to make the Association a well knit body—conscious of their entity and strength.

2. The income from yearly dues had not provided sufficient money to carry out the plans which had been proposed from time to time.

3. The complete change of officers each year resulted in a lack of continuity of effort.

4. The Constitution was rather archaic and had been amended and re-amended so frequently that its interpretation was uncertain.

Our first venture was a series of semi-monthly luncheons for the Chicago men. These fitted conveniently into a one-hour lunch period and were very well attended. They have been productive of many reunions and new friendships and have been a success from both a social and business viewpoint. We believe that their duplication in other cities will tend to constant contact essential to any Chapter organization.

The response to our plea for more local sections has been very gratifying. We have heard of activities in many sections and definite word from the following cities and organizers:

Detroit ....H. S. Ellington, '08.
Toledo ....C. R. Pomeroy, '17
New York ....G. B. James, '11
Kansas City ....B. F. Eyer, '02

Without doubt the number of sections will grow rapidly and provide a chain of active Armour men throughout the country who will wield the influence in engineering affairs which Armour well deserves.

A committee was soon appointed to consider the organization of other Alumni Associations and draft a constitution which would be suited to our needs. This was carefully worked out and adopted at the Mid-Winter meetings. It provides for concentration of power and a paid Secretary-Treasurer. The Officers and Board of Managers for next year will be elected by letter-ballot under this plan and the new Constitution will be in effect.

The Mid-winter meeting was held on January 18th at the University Club-Chicago, and proved a big success. The attendance of 173 was the largest that a Mid-winter meeting has drawn so far. The brief addresses and the entertainment provided by the A. I. T. Musical Club were enthusiastically received. The best feature of all was the splendid morale shown by those present.

After five months' consideration we decided that the only way to solve the finance problem was to make a drive for a $50,000 endowment fund. Upon investigation we found it quite feasible both as to time and amount. We are now well into the cam-

paign and the results are exceeding expectations. This fund will now provide for a business office with a paid Secretary-Treasurer to manage it. This will promote all Alumni activities and also serve as an employment office. We expect it to function after a few months preparatory work and are certain all will appreciate and benefit by it.

Frequently classes plan to meet a year or five years after graduation for a special class banquet and find that it is hard to notify the members and get their attendance. We have, therefore, taken this arrangement on ourselves and are offering the following plan:

> Every graduate make a special effort to attend the Spring meeting of the Alumni Association the year after graduation and every five years after that meeting.
>
> This year there will be a special reunion for the classes of 1897, 1902, 1907, 1912, 1917 and 1921. Every member of the classes is expected to be present at the Spring meeting and to get in touch with as many of his classmates as possible and urge their attendance.
>
> We do not want anyone to stay away because it does not happen to be a special reunion year for his class. The meeting is for everyone and the more there the better the occasion will be.

The Spring meeting will be held during the fourth week of May and we expect this to be a big home-coming occasion. Many of the members have written that they are planning to make a special trip to Chicago for the meeting.

Incomplete as many of our plans are, we feel that a solid foundation has been laid for further work and commend its successful completion to our successors.

Walter J. Bentley,
Corresponding Secretary.

PERSONALS AND CHANGES OF ADDRESS

1900

Martin, R. C., 919 E. 50th St., Chicago.

1906

Cutler, E. W., 1000 41st St., Sacramento, Calif. Manager, Service Station, Willard Storage Battery Co., 1508 Bay St., Sacramento, Calif.

Flanagan, F. J., 1524 W. 104th St., Chicago. Examiner, Committee on Finance, City Council, City Hall.

Scott, P. J., 1139 W. Caledonia St., Butte, Mont.

1908

Webb, A. R., 706 Calle Remedior, Manila, P. I. Professor of Civil Engineering, University of the Phillipines, Manila, P. I.

1909

Bexten, L. N., 9501 N. 35th St., Omaha, Nebr., Instructor of Applied Physics, Central High School, Omaha, Nebr.

1911

Jensen, R. F., 4600 N. Central Park Ave., Chicago, Ill. Assistant Engineer, Office of Bridge Design, Sanitary District of Chicago, 910 S. Michigan Ave., Chicago.

1912

Armstrong, R. C., Whareuna, Seaburn Ave., Caulfield, Melbourne, Australia. Instructor in Electrical Engineering, Melbourne Technical College, Melbourne, Australia.

Oehne, W. S., P. O. Box 165, St. Charles, Ill.

1913

Curtis, Marston C., Electrical Engineering, 1913. Now in Sales Division, General Elect. Co., Duluth, Minn. office. Curtis was associated with the Northwest Electrification project of the C. M. & St. P. Ry., from the commencement of the construction work, and rose to a position of superintendency of all sub-stations. He left that enterprise because change of climate was pertinent to improved health, and after a sojourn in the south moved to Detroit.

Kopald, Charles, 6107 Glenwood Ave., Chicago. Kopald Elec. Co., Contractors and Engineers, 2615 Lincoln Ave., Chicago.

Lundblad, Claus D., 1411 Webb Ave., Detroit, Michigan. Lundblad & Lundblad, Architects and Engineers, 206 Telegraph Bldg., Detroit, Michigan.

1914

Stecher, M. V., 588 Park Ave., East Orange, N. J. Superintendent of Power, Telephone & Telegraph, Western Union Telegraph Co., 195 Broadway, New York City.

1915

Sir, Walter W., 4156 Barry Ave., Chicago.

1917

Koch, left school before commencement to enter army service and has not returned to the school yet to receive his degree. Is now associated with the Texas Company, in the Sales Department, at their St. Paul office.

Maguire, H. B. With the American Steel and Wire Company, Sales Department, Detroit, Mich.

Luttge, Harold. With the Edison Power Co., Plant No. 2, Big Creek, California.

1918

Cole, E. R. With Byrne, Byrne & Hahn, 175 W. Jackson Blvd., Chicago.

Crown, V. M. Resident Engineer, Ulen Contracting Corp., Feroocaril Villazon, Atocha, Casilla 47, Tupiza, Bolivia, South America.

Nitka, Jesse. Asst. Labor Manager, B. Kuppenheimer & Co., 415 S. Franklin Street, Chicago. Jesse was recently married and is living at 5501 W. Adams St.

1919

Markham, J. H., 724 Cherry St., Grand Rapids, Mich. Chemist Grand Rapids Varnish Co., 565 Godfrey St., Grand Rapids, Mich.

1920

Renaud, E. S. Inspector, Testing Dept., Rock Island R. R., 47th and Wentworth Ave., Chicago.

1921

Brueckner, M. O., 1807 Bailey Ave., Chattanooga, Tenn. Assistant Dyer, Richmond Hosiery Mills, Rossville, Ga.

Maranz, Leo S., has recently been married.

OBITUARY

Donald A. Young, '10, was recently killed at Trinidad, California. He was employed at the Oakview Coal Co. mine and accidently came in contact with a 2300 volt line in their power house.

BOOK NOTES

MECHANICAL ENGINEERING

BATTLE, J. R.—*Handbook of industrial engineering.*

A complete revision of the author's Lubricating Engineers' handbook, 1916, together with the technology of petroleum and its products.

KETCHUM, M. S.—*Design of steel mill buildings.*

This new edition is a very thorough revision. All the data brought up to date, the section on steel mill building design completely rewritten and new specifications for steel frame mill buildings included.

LELAND, O. M.—*Practical least squares.*

Intended as a text for short courses in engineering colleges and as a reference book for the use of engineers and scientists in their private practice.

MARKS, L. S.—*Airplane engine.*

Formulates existing knowledge of the functioning of the engine and discusses the constructive details.

ROYDS, ROBERT—*Heat transmission in boilers, condensers and evaporators.*

Describes a few types of boilers. The chapters on condensers and evaporators are from experiments made in laboratories.

CHEMICAL ENGINEERING

AUSTIN, LEONARD—*Metallurgy of common metals.* New ed. . .

HATSCHEK, EMIL — *Laboratory manual of elementary colloid chemistry.*

Typical experiments, that might form a part of every course in chemistry.

LIND, S. C.—*Chemical effects of alpha particles and electrons.*

Outline of experimental results obtained in field of radio chemistry. Author is the physical chemist of the U. S. Bureau of Mines.

TAGGART, A. F.—*Manual of flotation processes.*

This book, in part, counteracts the further spread of the false conception concerning flotation concentration, by setting forth some of the essential facts which contradict them.